AMENDING THE GEOTHERMAL STEAM ACT OF 1970

HEARING

BEFORE THE

SUBCOMMITTEE ON PUBLIC LANDS AND RESERVED WATER

OF THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

NINETY-SEVENTH CONGRESS

FIRST SESSION

ON

S. 669

A BILL TO AMEND THE EXISTING GEOTHERMAL LEASING AND PERMITTING LAWS, AND FOR OTHER PURPOSES

S. 1516

A BILL TO AMEND THE GEOTHERMAL STEAM ACT OF 1970 (30 U.S.C. 1001 ET SEQ.) TO EXPEDITE EXPLORATION AND DEVELOPMENT OF GEOTHERMAL RESOURCES

CASPER, WYO., DECEMBER 12, 1981

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AMENDING THE GEOTHERMAL STEAM ACT OF 1970

SATURDAY, DECEMBER 12, 1981

U.S. SENATE,
SUBCOMMITTEE ON PUBLIC LANDS AND RESERVED WATER,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Casper, Wyo.

The subcommittee met, pursuant to notice, at 1:09 p.m. at the Ramada Inn, Center Street, Casper, Wyo., Hon. Malcolm Wallop, presiding.

Present: Senators Wallop and Melcher.

Also present: Tony Bevinetto, professional staff member; Roger Sindelar, counsel; Carol Garnett, chief clerk; and Thomas B. Williams, professional staff member for the minority.

OPENING STATEMENT OF HON. MALCOLM WALLOP, A U.S. SENATOR FROM THE STATE OF WYOMING

Senator WALLOP. Good afternoon. Welcome here. Welcome to you, especially, John.

Senator MELCHER. Thank you.

Senator WALLOP. It's a pleasure for me to have you here. And I know your long concerns and battles that you've laid on this issue. It's pretty particularly important that this be viewed in a bipartisan way as an issue as important and critical as the one that sits in front of us.

Also, just for my own sake, it's just always a pleasure to be back home.

Anyway, on to why we are here today, it gives me a particular pleasure to share what I consider to be a factfinding hearing of critical importance both to Wyoming and to Americans. This hearing is on the protection of the unique geothermal resources in Yellowstone National Park and peripherally in other units of the national park system in consideration of S. 1516 and S. 669.

The following excerpts from the 1980 final environmental impact statement of the Island Park geothermal area prepared by the Forest Service and the Bureau of Land Management summarizes well this uniqueness and frames the issue before this hearing today:

> The Geysers of Yellowstone National Park are the rarest of thermal features. There are 200 of these erupting hot springs inside the Park, more than in the rest of the world combined. Of the ten major geyser areas in the world, Yellowstone ranks first. In the last three decades, seven of these ten areas have been destroyed or damaged by geothermal exploration or development.
>
> Geysers depend on a dynamic yet fragile system which can be easily disrupted. In the case of Yellowstone geysers, there is a source of heat relatively close to the surface which heats an abundant supply of groundwater. This water circulates easily and a great depth through fractured volcanic rock and glacial

gravel cemented together by mineral deposits from the hot water. Periodic eruptions apparently take place because constrictions in the underground passageways cause water to become superheated then flash into steam. Any alteration of heat or water that flows through these natural systems can cause the "plumbing" to dry out, disintegrate, and no longer produce Geyser action.

The exact boundaries of the Yellowstone geothermal reservoir or reservoirs are uncertain, and no definite evidence is apparently available on what the permeability is at depth. Thus, it is difficult to say how much of a connection, if any, there is between the possible geothermal resource of the Island Park geothermal area and thermal areas inside the park, or if any adverse effects might result.

The thermal areas of Yellowstone National Park are important not only for the hot springs, geysers, mud pots, et cetera, which lie within its margins. The natural heat flow and hot water discharge is critical to the wildlife in the park. Bison, elk, trumpter swan, Canada geese, and many other waterfowl congregate in the thermal areas or on the rivers during the winter months.

The conclusion is painfully clear. No one knows whether or not geothermal development of the Island Park geothermal area will adversely affect Yellowstone.

In 1979, the Department of Geology at the University of Wyoming analyzed previous studies of thermal activity in Yellowstone and potential development west of the park. The several types of "imagery" previously used to evaluate the study area were analyzed and interpreted by the authors Levinson and Marrs, including airborne thermography, color and color infrared aerial photography, black and white orthophotography, satellite scanner imagery and side-looking radar imagery. They interpreted the information as indicating "several thermally anomalous areas," and finding that " a northeast/southwest trend in the identified linear features indicates a potential link between the Yellowstone and Island Park thermal areas."

I am pleased that—well, I was pleased that Mr. Marrs was going to be here today; but he will submit his report. It would have been useful, I think, to all of us to have been able to make inquiry on that.

I wish to make it quite clear at this point that I do not oppose geothermal development, per se. I have been a strong proponent of alternative domestic energy resources. Geothermal is potentially one of the most attractive alternatives. Geothermal energy is one of the oldest known resources and one of the largest single sources of energy. It is a source of energy not without serious environmental problems, particularly hydrogen sulfide discharges. However, upon comparison to development of fossil fuels and nuclear energy, geothermal energy can be produced with substantially less land disruption and residual discharge, be it air or water.

The U.S. Geological Survey estimates that as much as 95 million acres of land, mostly in the western third of the United States, including Alaska and Hawaii, have potential for geothermal development. Sixty percent of that potential is further estimated to be located on federally owned land. Even though the Federal Government has spent over $500 million in the past 5 years to accelerate geothermal development, and the Federal leasing program was initiated back in January of 1974, there has been effectively no commercial production resulting on the Federal lands. We have a single greenhouse in New Mexico and three electric power generating plants in California, the geysers project in Sonoma County producing 912 megawatts, and the Brawely and East Mesa projects, both in the Imperial Valley and generating 10 megawatts each.

Some of the obstacles attributed this lack of development stem from a combination of legislative, economic, technical, and regulatory factors, let alone the sheer risk of accompanying any speculative, fledging industry.

The intent of Senators Warner's and McClure's bills, S. 1516, is to cure the defects made evident in the last 11 years since the enactment of the Geothermal Steam Act of 1970. What we are weighing here today is the need to provide special protections for Yellowstone National Park.

I appreciate Senator McClure's view that existing law provides the Secretary of the Interior with ample authority to protect the geothermal features in any of this Nation's national parks. Interior goes further yet in recognizing that: "The public deserves absolute assurance that their national parks will not be damaged in any way."

The quote is from the October 27, 1981, statement of Dave Russell, Deputy Assistant Secretary for Land and Water Resources before the Subcommittee on Energy and Mineral Resources. Interior subscribes to the park language found in the corresponding House geothermal bill, H.R. 4067, which provides a 15-mile buffer for Yellowstone and a 1-mile buffer for Lassen.

I generally agree with Senator McClure, that existing law may give the Secretary of the Interior sufficiently broad discretion to protect the national parks against exploitation. Yet that is not adequate as it relates to Yellowstone, nor do I think the House's provision adequate either. I have heard no scientific justification for the 15-mile buffer, and more particularly the buffer zone does not include the Island Park caldera where the real potential of development lies.

We just are going to have a problem if and when we should make that decision on the basis of what I think testimony today will indicate as the state of our knowledge.

Now, the recommendation for development in Island Park by the Forest Service and the Bureau of Land Management is to issue the leases. And I might add that there are 200 applications pending, requiring a monitoring system and a stipulation that operations will be suspended if development "significantly influences pressures, chloride concentrations, or temperature of the monitored features * * *."

Now, I personally feel, with the lack of information we have up to date, that we would be making a hell of a mistake in leasing in Island Park. I have not been persuaded of the effectiveness of monitoring systems and the fear that irreversible damage may have occurred before any indication of damage is found.

Moreover, the track record in destroying geothermal features is phenomenal. The Forest Service in its Environmental Impact Statement on Island Park, indicated the sort of thing that can happen. In that Impact Statement, the Forest Service provides one history lesson, and I quote:

> . . . In New Zealand, for example, the Wairakei plant was installed during the early 1950's. By 1954 the Great Geyser in Geyser Thermal Valley which ranked fifth among the major geyser areas of the world, became inactive coincident with Wairakei's declining reservoir pressure. All other springs and geysers in the valley were also diminishing in their discharge of hot water. And the last known natural geyser eruption occurred around 1965.
>
> Geyser Thermal Valley was closed as a tourist attraction in 1972, and the Karapiti Blowhole ceased activity in 1973. Further production from Wairakei

also affected another thermal area thought to be independent with no connection at depth. Recent drilling nine to twelve miles from Waiotopu, another New Zealand thermal area, may have induced a chemical change or "interference" within its reservoir.

Near cessation or total destruction of natural hot springs or geyser activity from adjacent geothermal development is not limited to New Zealand. Similar changes have been recorded in Iceland; Lardarello, Italy; Beowawe, Nevada; and Steamboat Springs, Nevada. The Beowawe Geysers of Nevada were second to Yellowstone on the North American continent in amount of activity before the period 1945 to 1958 when geothermal exploration began. Wells were drilled and permitted to discharge while not converted to commercial use. By 1961 all springs and geysers had ceased flowing. Without the natural continuous supply of hot water levels dipping below the surface, the geyser hot spring formations rapidly disintegrated due to desiccation and frost expansion.

A similar destruction of the small geysers of Steamboat Springs, Nev., occurred in response to geothermal expioitation between 1950 and the early 1960's. In the case of Yellowstone National Park, a number of its natural hot springs areas lie within 12 miles of the Island Park geothermal area.

Now, I'm sure that you can all appreciate my concern. And I encourage witnesses to explore any and all alternatives to this.

The hearing record will remain open for 2 weeks after today. Statements may be submitted to the Public Lands and Reserved Water Subcommittee, 3104 Dirksen Office Building, Washington, D.C. 20510, or to my office here in Casper, 2201 Federal Building, Casper, Wyo. 82601.

Those persons who wish to receive a printed copy of the hearing record should print their names and addresses on the mailing labels provided outside the door here on the table by the sign. And the printed hearing should be available in 2 months.

And if you want to know what I think is the ultimate and final bottom line in all of this, I just would ask what it would be like to be president of the company, the man who built the well and that turned off the Old Faithful Geyser. That's the root of what we're doing.

I have no objection to doing it if somebody can prove to our satisfaction that that won't happen. I mean, all these reports and all the other things really come down to that one thing. How would you like to go down in history as the one who did that? I know John Townsley wouldn't like to be the superintendent who had to set the park as a geothermal depression. None of us would, and is really what the bottom line of the hearing is today.

John, do you have a statement?

STATEMENT OF HON. JOHN MELCHER, A U.S. SENATOR FROM THE STATE OF MONTANA

Senator MELCHER. Thank you, Mr. Chairman.

I am very much appreciative of the fact that you've held this hearing. It's very important to us in Montana. We view joint ownership of Yellowstone with Wyoming, having access to it from three different directions. It's a tremendous resource value that we are very proud of in Montana.

I've been very interested in this general subject for a number of years. I've served as chairman of the Subcommittee on Forestry, Water Resources, and Environment of the Senate Agriculture Committee.

In July of 1979, we continued a hearing on the impact of geothermal exploration in Targhee National Forest. That hearing addressed the then draft environmental impact statement which was prepared by the Forest Service as a lease Federal agency to develop that EIS. And it became final on January 15, 1980; although, the decision to adopt the preferred alternative is currently being appealed.

There have been a number of legislative proposals to protect important thermal features located inside the national parks. These proposals have been discussed by Congress from time to time in the last several years. It's not clear at this time what specific language Congress will adopt regarding the issue. The purpose of our hearing here today, I gather, is to be brought up to date by our witnesses.

Deputy Assistant Secretary David Russell of the Interior Department reflected the feelings of many of us in his statement before the Senate Committee on Energy and Natural Resources on this matter in October when he said:

> We believe the public deserves absolute assurance that their national parks will not be damaged in any way.

Now, we are all going to agree that geothermal resources are a good source of energy. They are good, clean energy; but I hope we all agree that they are good sources of energy at the expense of damaging Old Faithful and the other geysers in the park or other geothermal features in Yellowstone.

Malcolm, you mentioned problems regarding swans, geese, and ducks wintering on the Madison River. My wife and I and some friends from McLean, Va., drove into Madison Junction last winter between Christmas and New Years. We were greatly impressed with the amount of wildlife one can see in a very short drive. It's very rewarding to watch buffalo 75 feet away scratch themselves on rocks or walk amongst scores of rather tame elk.

This is a part of the future of the park that leaves accessibility, very easy accessibility. We can see wildlife and waterfowl in the wintertime on the Madison because of the geothermal features of the park.

In the 1979 hearing, Assistant Secretary Herbst, Assistant Secretary for the Parks, testified about the losses of the Nevada geyser fields which were second only to Old Faithful in North America. This occurred as recently as the 1950's.

And now we have Old Faithful left. Old Faithful and the rest of the geysers in the park comprise the only significant geyser system in the United States. And as you've stated, I believe, there are only three really good geyser systems in the world. There are four that are partially active, and three of the major geyser systems known in the world have completely disappeared.

Herbst said in that July 1979 hearing, "There is no geothermal development in the world within a geyser basin area that has been done without adverse effect on the geysers."

A question raised continually concerns buffer zones. Herbst said in 1979, "The exact boundaries of the geothermal reservoirs that supply Yellowstone are currently unknown."

We do not know how much of a connection there is between the proposed lease areas and the thermal areas inside the park. We therefore do not know what adverse effects on park resources might result when geothermal leasing proceeds in the Island Park geothermal area.

Well, that was in 1979. Now we are here today to see whether anybody can contribute any additional knowledge. I daresay there will not be any knowledge of substance that will assure us that development in the Island Park area, that close to the park, can be done without damage to the geysers and geothermal valleys inside the park.

Now, we have bills. The House bill provides for a 15-mile buffer zone around Yellowstone.

The better part of wisdom this year will be to take one of the several routes that we can take in Congress to prevent any possibility of damage within the park. We can do it by legislation or we can do it by emergency withdrawal.

I'm very pleased to listen to an update from our witnesses today. I am interested in what the State of Idaho has to say because some of its land is in this area. I'm willing to take into account all of the known positive information that is available. But to do anything, to allow anything to happen in this area that might threaten the park, no way. No way. It's just too great a chance to take. And I believe Malcolm and I are in agreeement. I would be delighted to listen to the evidence that will be presented.

Thank you very much.

Senator WALLOP. Just to point out before we get underway, there was some worry throughout most of this week as to whether or not we would be allowed to hold a formal hearing of this committee. One Senator was threatening to object to it if the Senate were to be in session today. Fortunately, it was not. To give a measure of how persistent we were that this information be put on the record before any kind of Senate activity took place, we were going to pay the cost of the reporter and other things ourselves in order not to disappoint those who came to testify and in order, particularly, to not divert or prolong our information-gathering process.

Fortunately, we didn't have to do that.

Senator MELCHER. We were going to meet come hell or high water.

Senator WALLOP. We are going to break into panels this morning or this afternoon, and the first panel consists of Mr. John Townsley, Superintendent of Yellowstone National Park; Raymond Herrmann, Director of Water Resources Laboratory, National Parks Service; Dr. Robert Fournier, geologist, U.S. Geological Survey; Dr. Robert Christiansen geologist, U.S. Geological Survey; and Mr. William Johnson, who was to have been here from the Forest Service, but will not be with us—oh, he is. I'm sorry. All right. Mr. Johnson, Director of Minerals Area Management, region IV, U.S. Forest Service.

Can we have you gentlemen come up and proceed with this?

John, are we ready?

STATEMENT OF JOHN TOWNSLEY, SUPERINTENDENT, YELLOWSTONE NATIONAL PARK, NATIONAL PARK SERVICE, DEPARTMENT OF THE INTERIOR

Mr. TOWNSLEY. Senator Wallop, Senator Melcher, Mr. Chairman, I am John Townsley, Superintendent of Yellowstone National Park. I am pleased to be invited to appear before your committee and present this statement on behalf of the world's oldest national park; to de-

scribe something of Yellowstone's special resources and their values for today's society.

Senator, is it your pleasure that I read the statement or submit it?

Senator WALLOP. You can read it and summarize it or expand upon it or speak on something different, as you wish.

Mr. TOWNSLEY. I think my preference would be to simply read it.

Senator WALLOP. Go ahead, by all means.

Mr. TOWNSLEY. Yellowstone, the place: In the early years of our Nation, the Yellowstone region was long considered too remote, too much out of the way to attract any serious attention from explorers and settlers. Only a few fur trappers followed the Yellowstone River to its headwaters on a high plateau almost surrounded by mountains of the Northern Rockies.

When organized parties finally explored the Yellowstone region a little over 100 years ago, the Nation learned of its wonders which had to be seen to be completely believed. Descriptions of exploding geysers, boiling springs, roaring steam vents and a decorated canyon were soon published, while art and photography recorded them visually. Americans were so delighted with this new found wonderland that the 42d Congress swiftly acted to withdraw 2.2 million acres from settlements, and in March 1872 made it into something never heard of before, a national park for the benefit and pleasure of the people.

The Secretary of the Interior was instructed to make rules and regulations for the "preservation from injury or spoilation of all timber, mineral deposits, natural curiosities or wonders of said park, and their retention in their natural condition."

Generous boundaries were drawn to be sure all the most special features, geysers and hot springs, were included.

Congress intent in designating Yellowstone was to totally protect the park's thermal features. This intent was reaffirmed by the Congress in 1978, when the Secretary of the Interior was instructed to guard against actions which might compromise the values and purposes of the national park system. Public Law 95–250.

What was achieved by creating Yellowstone National Park? Most important of all, the world's largest concentration of rare geysers is guaranteed protection. Over 200 of the park's estimated 10,000 thermal features have exactly the right combination of heat, natural "plumbing" systems, and flow of water to have eruptions. Geysers vary from the predictable famous Old Faithful to sputtering Tom Thumb Geyser in the bottom of the Grand Canyon of the Yellowstone. Geyser action is one of the world's rarest natural phenomena, and Yellowstone has more geysers than the rest of the world combined.

It is estimated by a world expert on geysers, Dr. Donald E. White, that only about 10 geyser areas in the world were truly outstanding and three or possibly four of these have been profoundly altered by nearby commercial thermal development. Three others were affected by other activities of man such as construction of dams. Only those in Yellowstone, Iceland, and the U.S.S.R. are essentially undisturbed.

The volcanic energy which drives Yellowstone's hot springs has in the past erupted explosively to create a landscape of volcanoes, lava flows, canyons, lake basins and plateaus. Chains of volcanoes in the Yellowstone region repeatedly buried living forests with ash 50 million years ago, just as Mount St. Helens did in 1980. Today petrified

stumps and logs are reappearing in Yellowstone as erosion uncovers the world's most extensive fossil forest.

Yellowstone's volcanoes died away, but an underground chamber of molten rock and gas eventually exploded in a series of vast eruptions that would have dwarfed the Mount St. Helens eruption. This blast blanketed hundreds of thousands of square miles with debris and left a smoking, sunken crater or caldera 30 by 40 miles in size. Lava flowed into the depression, obscuring its outlines. Most of Yellowstone's inner plateau and its 139-square-mile lake now lie within the caldera rim, all within the park boundaries. The most recent caldera explosion occurred only 600,000 years ago. And much evidence indicates that the magma chamber still exists near the surface. There is a potential for future episodes.

Yellowstone's famous Grand Canyon also has its roots in the volcanic past. Lava flows were bathed from below by hot water, softening as well as coloring them through chemical action. Unaltered lava, beyond the reach of the hot water, became the resistant brink of its waterfalls.

In addition to its thermal features, Yellowstone National Park provides a great diversity of outstanding natural and historic resources. The park itself is centered in what might be called the Greater Yellowstone Area, 5.5 million acres of mostly public land. This includes Yellowstone and Grand Teton National Parks, J. D. Rockefeller Parkway and five national forests: The Bridger-Teton, Gallatin, Shoshone, Targhee, and Custer.

The 2.5 million visitors who come each year to Yellowstone Park see not only thermal and scenic wonders, but also wildlife living undisturbed in the sanctuary of the park. Bison, elk, deer, pronghorn, bighorn sheep, and fish coexist with their natural predators and neighbors such as mountain lions, coyotes, bear, eagles, pelicans, and otters. During long winters with deep snows, many species seek thermal areas for their survival, sharing the Old Faithful area, for instance, with winter visitors who reach it by snowcoach, snowmobiles or skis. Soon after Yellowstone National Park was established, full protection was extended to its wildlife, providing a sanctuary for animals to live undisturbed in their natural environment.

The 1872 concept of Yellowstone National Park as a "pleasuring ground" was different in many ways from that of today. The public desired greater protection of all of the park's resources, while increasing experience and knowledge in managing natural environments led to more responsible decisions and actions. Congressional actions over the years clarified and defined Yellowstone and other national parks and gave mandates for their management.

I have submitted, Senator, a list of that. It's outlined here, and if you would like a copy of that for the record, we would be pleased to provide that for you.

Senator WALLOP. We'll just include it in the record.

[The list follows:]

Laws which have provided parts of legal framework for Yellowstone National Park include:

March 1, 1872—Yellowstone National Park is established (17 Stat. 32, U.S.C. sec. 22).

July 10, 1890—Wyoming is admitted to the Union and limits its authority over Yellowstone National Park (25 Stat. 222).

February 7, 1981—Idaho cedes exclusive jurisdiction of lands within Yellowstone NP to Federal Government (session laws of Idaho, 1890–91, p. 40).

February 14, 1891—Montana cedes jurisdiction of lands within Yellowstone NP to Federal Government (laws of Montana, 1891, p. 262).

May 7, 1894—Statutory protection is provided for birds and animals in Yellowstone NP (28 Stat. 73; 16 U.S.C. sec. 24–30).

March 4, 1909—Punishment is provided for damage to public lands (35 Stat. 1098, 18 U.S.C. sec. 112).

August 25, 1916—National Park Service is established to consolidate civilian administration of our national parks (39 Stat. 535, U.S.C. 16 sec. 1, 2, 3, 4).

May 26, 1926—Winter range for elk, antelope and other game animals of Yellowstone NP is improved and extended (44 Stat. 655; 16 U.S.C. sec. 37–40).

March 1, 1929—Northern, northeastern, and eastern boundaries of Yellowstone NP are revised (45 Stat. 1435, 16 U.S.C. sec. 21).

October 20, 1932—Executive proclamation enlarges park by revising north boundary.

June 10, 1933—Executive proclamation reorganizes Government and creates national park system under the National Park Service.

August 8, 1946—National parks and monuments are exempted from Mineral Leasing Act of 1920 (60 Stat. 950, 30 U.S.C. sec. 181).

December 24, 1970—Geothermal leasing is authorized except in national parks (84 Stat. 1566 U.S.C. ———).

August 7, 1977—Guidelines and standards are established for class I air quality areas (91 Stat. 685, P.L. 95–59).

Mr. TOWNSLEY. Thank you.

This legislation taken together clearly provides ample authority to protect Yellowstone National Park. Coupled with the additional protective measures contemplated by H.R. 4067, sponsored by Congressman Marriott and Santini, these laws will provide the mandates and discretionary authority needed to insure the preservation of this unique and world reknowned resources.

Yellowstone, its value in today's world: The incalculable value of Yellowstone National Park cannot be measured in any monetary terms, because it has become a national and international treasure. Our Government has awarded its most protective status by making it a national park. The world community added to that recognition when the United Nations Educational, Scientific and Cultural Organization, UNESCO, designated Yellowstone as an international biosphere reserve as well as a world heritage site.

Two and a half million visitors per year now include members from Europe and Asia, in addition to our Canadian neighbors.

The Park Service, the Department of the Interior and Secretary Watt, and the Director of the National Park Service are personally committed to insuring that, under no condition, will activities be allowed that could damage these natural wonders. Yellowstone's resources hold a special place in the hearts of all Americans. It is our responsibility as stewards of this Nation's lands and resources to do everything we can to insure that millions of Americans, both now and in the future, can continue to enjoy their splendor.

Director Dickenson, in his statement to the Senate Energy Committee on October 27, 1981, recommended that any geothermal legislation include language providing for a no leasing buffer zone around Yellowstone National Park to eliminate the possibility that the park's geothermal features might be harmed because an underground source of those features is tapped from lands outside the park.

He also recommended that such park protection language give the Secretary discretion to require that lessees of lands outside this buffer zone establish monitoring programs; to use resulting informa-

tion to modify the buffer zone boundaries, when necessary, to provide for additional protection; to require reinjection of any water produced in the exploration or development process; and to halt immediately any activities which may cause adverse effects on the park's nationally significant thermal features.

The National Park Service understands that current geological and other scientific evidence indicates that only a relatively small buffer zone is necessary to protect Yellowstone National Park if it is combined with monitoring, reinjection, and other discretionary authorities like the ones previously mentioned.

The only exception to this 15-mile buffer, as provided by H.R. 4067, would be for the Island Park caldera. Under H.R. 4067, the Secretary is authorized to allow geothermal leasing within designated portions of the caldera, but subject to these special protective measures to insure that Yellowstone National Park's nationally significant thermal features are safeguarded in every possible way.

If these protection provisions are enacted into law, the National Park Service believes that geothermal exploration and development can be permitted in those portions of the Island Park area located outside the no lease exclusion zone shown on the map without resulting in adverse impacts to the geothermal features within Yellowstone National Park. The Service is confident that the additional authorities requested will enable the Department of the Interior to respond promptly to any apparent changes or threats to the Yellowstone thermal features, and insure their continued protection.

Thank you very much for your time, Mr. Chairman. I would be happy to respond to any questions you or members of the subcommittee might have.

Senator WALLOP. Thank you.

John, I think what we'll do, if it's all right with you, John, is to go right on through and hear from Dr. Herrmann.

STATEMENT OF DR. RAYMOND HERRMANN, DIRECTOR, WATER RESOURCES FIELD SUPPORT LABORATORY, NATIONAL PARK SERVICE, DEPARTMENT OF THE INTERIOR

Dr. HERRMANN. Mr. Chairman, Senator Melcher, my prepared statement has been submitted for the record.

What I would like to say is I am a geologist with the National Park Service. I have been involved in coordinating geothermal activities with the USGS for the last 2 years. We have done one specific thing since 1979, which was mentioned earlier. And that was to conduct a study with the University of Utah to try to gain some additional subsurface information on the area between Old Faithful or the Yellowstone geothermal features and the Island Park area. That study was inconclusive. We were not able to draw any new conclusions about the subsurface hydrothermal or hydrological activities.

I think that concludes my statement. And I am also available for questions.

[The prepared statement of Dr. Herrmann follows:]

STATEMENT OF DR. RAYMOND HERRMANN
DIRECTOR OF THE NATIONAL PARK SERVICE
WATER RESOURCES FIELD SUPPORT LABORATORY
BEFORE THE SUBCOMMITTEE ON PUBLIC LANDS AND RESERVED WATER
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
CONCERNING PROTECTION OF GEOTHERMAL RESOURCES IN
YELLOWSTONE NATIONAL PARK

Casper, Wyoming

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I am a registered professional geologist and have been the interagency technical liaison for geothermal activities involving the National Park Service for the past 2-1/2 years. I have reviewed the pertinent literature about Yellowstone National Park and the Island Park Area. I have also been responsible for coordinating National Park Service activities with the various elements of the U.S. Geological Survey. I appreciate the opportunity to discuss Yellowstone National Park and the pending geothermal legislation.

As you know, the National Park Service does not have the scientific resources within the agency needed to fully assess the numerous resource issues facing the agency. Thus, we recognize the USGS as the technical authority on geothermal resources and have relied on their analyses and evaluations to assist us in developing geological evidence when needed for park management.

In the case of Yellowstone, the National Park Service has cooperated over the years with the Geological Survey to further define sources of thermal features. Based on available geologic and geophysical data, as well as USGS analyses and interpretations, we have been able to delineate an approximate boundary of the Island Park Caldera. A portion of this caldera is identified on the map as a zone available for geothermal leasing. The Geological Survey has concluded that restricting leasing to the caldera, combined with proper monitoring and reservoir protection procedures, will allow for exploration

within the Island Park Caldera --and development if a resource is found -- while still protecting the Park's major thermal features.

I want to point out that, at the request of the National Park Service, Dr. R. G. Smith, a nationally respected seismologist at the University of Utah, in conjunction with Purdue University, expanded upon a study supported by the USGS and recently conducted a seismic survey of the Madison Plateau between the Yellowstone Caldera and the adjacent Island Park Caldera. The purpose of this survey was to attempt to derive subsurface geological information from which inferences could be made about the hydrothermal conductivity. Analysis of the seismic survey data proved to be inconclusive and no hydrologic conclusions were drawn from this study.

I am at this time unaware of any direct geologic data which refute or support the proposition that a specific buffer exclusion area permitting geothermal development in the Island Park area will, by itself, protect the thermal features of the Park. Nevertheless, based on the technical information currently available to me, it is my opinion that geothermal development can be permitted in those portions of the Island Park area located outside the exclusion zone shown on the map, without endangering the major thermal features of Yellowstone National Park, provided that the fluids extracted from each well are required to be reinjected in a manner designed to maintain fluid pressure within the geothermal reservoir at its preproduction level.

This concludes my prepared statement. Thank you very much for the opportunity to be here. I would be happy to answer any questions you might have.

Senator WALLOP. Generally speaking, was what you just said a summary of your statement?

Dr. HERRMANN. It's a summary of part of my prepared statement, yes, sir.

Senator WALLOP. OK. Dr. Fournier?

Dr. FOURNIER. Senator Wallop, Dr. Christiansen is here with the U.S. Geological Survey, and he will read the prepared statement. I am here primarily to provide technical backup for any questions you might have.

Senator WALLOP. OK.

STATEMENT OF DR. ROBERT L. CHRISTIANSEN, GEOLOGIST, U.S. GEOLOGICAL SURVEY; ACCOMPANIED BY DR. ROBERT O. FOURNIER, GEOLOGIST, U.S. GEOLOGICAL SURVEY

Dr. CHRISTIANSEN. Thank you, Mr. Chairman. I am Dr. Robert L. Christiansen of the U.S. Geological Survey in Menlo Park, Calif. I am here today to testify on the subject of this hearing from the viewpoint of a research scientist. I am a geologist in the Survey's Geologic Division, and my specific background includes volcanological and geothermal research for the past 20 years. I was the program manager of the Survey's geothermal research program from early 1976 to late 1979, and I organized the Survey's volcano-monitoring program at Mount St. Helens in 1980.

I have been studying Yellowstone's volcanic features since 1966, including geological mapping, volcanological analysis and rock-chemistry studies of both Yellowstone National Park and the area of Island Park just to the west.

I am accompanied this afternoon by Dr. Robert O. Fournier, also of the Geological Survey in Menlo Park, Calif. Dr. Fournier is a world-recognized expert in geothermal studies. He is a geologist and geochemist in the Survey's Geologic Division whose research concentrates on studies of geothermal fluids and chemicals interactions between geothermal fluids and the rocks through which they flow.

Dr. Fournier has carried out considerable research in Yellowstone National Park over the past 21 years. He has twice served as a consultant to the National Park Service on matters dealing with man-induced disruption of hot springs in the park. Thus, both of us have had extensive field experience in Yellowstone National Park and vicinity.

In the statement is a brief background on the studies of the Geological Survey, which I will not read to you right now. Let me summarize briefly some of the status of our existing knowledge of Yellowstone and Island Park system.

Senator WALLOP. May I ask you to be—and this is a rare thing, but not to be too brief; because we are really trying to——

Dr. CHRISTIANSEN. I'll be glad to. Just to give you a background on the program, I'll be glad to read it.

Senator WALLOP. The background is all right. You were going to talk about the status of your existing knowledge, and that is my existing knowledge and your existing knowledge is——

Dr. CHRISTIANSEN. This will be very brief in general. I will be glad to amplify it as questions are asked.

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Let me provide a little background on the studies that are carried out in the Survey's geothermal research program. We conduct nationwide studies aimed at increasing our knowledge of the character, distribution, and magnitude of geothermal resources. These studies include evaluation of the hydrology and geology of various important geothermal areas. We also analyze techniques for geothermal exploration and some geoenvironmental effects of development, including developing models of the hydrology of geothermal systems.

The Survey has another geothermal program, concerned with the leasing of Federal lands, carried out in the Survey's Conservation Division. The research and the leasing programs are separately managed because of their distinctly different missions, but they are coordinated in both their planning and implementation stages. Once again, I speak only from the scientific viewpoint from my experience in the Survey's geothermal research program.

There are a number of points relevant to the purpose of this hearing which we can discuss from the perspective of scientific research in and adjacent to Yellowstone:

A wide range of geoscientific studies converge to show that the major geothermal features of Yellowstone Park are related to the heat of a very large subsurface chamber filled with magma. Magma is the geologist's term for a naturally occurring mass of molten rock and dissolved gases within the Earth. This magma chamber lies beneath the volcanic plateaus of Yellowstone National Park, probably below a depth from about 3 to 5 miles, and has been the source of one of the world's most voluminous volcanic fields.

This volcanic field was erupted cyclically three times over the past 2 million years, each cycle climaxing with the eruption of enormous quantities of volcanic ash and pumice in such short time that the roof of the magma chamber was left without support and collapsed to form a gigantic crater-like depression, or caldera. The Yellowstone magma body apparently has been solidifying and cooling for at least the past 100,000 years. It is uncertain whether part of the body is still molten; although, several lines of evidence suggest that it is.

Whether or not it is still partly molten, it is hot, and it provides the thermal energy for one or possibly more systems of hydrothermal convection in the rock above it. A hydrothermal convection system consists of circulating subsurface water that is fed by downward-percolating cold groundwater which is heated at considerable depth, causing it to rise and a portion of it to discharge at the surface as the famous geysers, hot springs and steam vents of Yellowstone National Park.

I'll amplify what is written and briefly say that Yellowstone's is heated by the magma body of the third of these volcanic cycles that I have mentioned before. Island Park lies to the west in an area that was affected only by the first and second volcanic cycles. And it has been cooling for a million years longer. Thus, we can say that a similar but older magma body may be the heat source in the Island Park area; however, even if multiple hydrothermal convection systems are powered by these contiguous heat sources, they are not necessarily in hydrologic connection.

I'll briefly now summarize for you some of the ongoing research and study programs.

Many geoscientific groups and institutions are involved in work at Yellowstone. One of these, the USGS, maintains the most comprehensive program of research. But it cooperates with others, especially the University of Utah. Present research is focused on the active processes of earthquakes, deformation of the ground surface, hydrothermal circulation and noneruptive volcanic processes.

To accomplish the research objectives, an integrated interdisciplinary approach is used, combining the efforts of geologists, geochemists and geophysicists. Some of the studies concentrate on the nature of Yellowstone's earthquake activity and the nature of possible future eruptive activity of the Yellowstone volcanic system.

Of particular interest to date are the studies aimed at compiling a baseline of data about levels of hydrothermal activity and natural fluctuations in the hydrothermal systems of the park in order to understand better he changes that occur naturally in relation to changes that might be induced by commercial geothermal development in areas near but outside the park.

Now, to address the question of whether there is scientific truth that buffer zones can protect the geothermal features in the park.

There is no doubt that a buffer zone provides a margin of protection; however, there is no sound scientific basis to define the minimum width of a buffer zone needed to insure protection of thermal features.

Past experience at various geothermal areas around the world have shown that geothermal development and exploitation may adversely affect nearby natural geothermal phenomena such as hot springs and geysers. For example, depletion of geysers was the effect experienced in New Zealand where the exploited and affected areas were separated by as much as 2½ miles, the greatest distance over which an adverse effect has yet been observed.

However, it should be noted that in all other known examples, the natural thermal manifestations that were adversely affected were much closer, if not immediately adjacent, to the areas of exploitation; and that no attempt to mitigate such effects, for example by reinjection, were made. In other words, in situations where geothermal development occurs in relatively close proximity to thermal features and no mitigating efforts are undertaken, some adverse effects are to be expected.

In terms of Yellowstone National Park, one should keep in mind that no geothermal energy resource is yet known to exist in adjacent areas, including the Island Park area. If the position and size of such a hypothetical resource were known, the delineation of the buffer zone for Yellowstone could be attempted on a sounder basis.

Perhaps the most significant point to be made about buffer zones in general relates to a distinction between two types of geothermal systems: hot water systems and vapor dominated systems.

Surface geothermal phenomena associated with hot water systems are in direct hydrologic connection with a subsurface geothermal reservoir, and are therefore relatively sensitive to changes in the subsurface hydrologic regime.

Surface geothermal phenomena associated with vapor dominated systems, however, are not in direct hydrologic connection with an underlying geothermal reservoir. The heat and some of the water of geothermal features of this sort are provided by steam that rises from

depth and that condenses at or near the Earth's surface. Thus, in general, a buffer zone is of relatively less importance for vapor dominated systems.

The thermal features of Lassen Volcanic National Park are of the vapor dominated variety. Those of Yellowstone, considered as a single complex system, are of the hot water variety.

Furthermore, with either type of system it must be realized that even a considerable withdrawal of heat alone is not sufficient to affect the natural hydrothermal features at a distance of more than a few feet. Only the diversion of geothermal fluids in large quantities by geothermal production would have even the remotest possibility of affecting the hydrothermal features of physically separated areas.

Dr. Donald E. White of the U.S. Geological Survey, one of the world's preeminent authorities on geothermal systems, has analyzed the areas of the world where geysers and hot springs have been altered by the effects of geothermal production in nearby areas. The greatest distance noted by White between a producing field, hot water system, and the affected hot springs or geysers of a separate area is in New Zealand at Wairakei and Tauhara, where a distance of as much as 2½ miles separates them.

With this limited experience as our only guide, it would seem that a buffer distance of a few miles between an area of commercial geothermal production and the nearest natural hydrothermal features of a hot water system would afford a reasonable margin of safety where more specific location information is unavailable. Less of a buffer should be needed for a vapor dominated system.

It is important, however, to note that specific, local geologic features would govern possible hydrologic interconnection between areas of concern and would determine the nature of any hydrothermal pressure gradients between them.

Now, I realize that was going over a lot of territory very quickly. And if there are any parts that should be clarified, we will certainly do so.

I turn to the point on how effective might reinjection be to provide protection to park geothermal features.

Reinjection refers to pumping geothermal fluids back into the subsurface after useful heat has been extracted. Though not universally practiced, reinjection at developed geothermal areas is common because it helps to maintain fluid pressure in a geothermal reservoir and thus to potentially extend the useful life of the system. It may also provide a solution to certain environmental considerations.

Theoretically, reinjection can entirely mitigate any adverse effects on natural thermal manifestations that might result from exploitation of a nearby system.

The key is to maintain fluid pressure in the geothermal reservoir at its preproduction level. Under such conditions, it is virtually impossible for fluids to be diverted from nearby natural features by the process of exploitation in an adjacent area, regardless of the quantity of thermal energy extracted from the exploited system.

Thus, a carefully designted program of reinjection provides a powerful tool for protection of natural thermal features.

Now, there are possible protection strategies. Since the key to protecting natural thermal features from man-induced disturbances is

to avoid changing the natural distribution of fluid pressure in geothermal systems, a program of monitoring such pressure in wells positioned close to the developed area and between this area and features that may be adversely affected can provide an early warning of a potential adverse effect. Monitoring fluid pressure in wells properly positioned and designed can accomplish this objective.

In summary, we know a considerable amount of the geology and geothermal systems of the Yellowstone region, but we do not yet know if a geothermal resource exists in the Island Park area. If such a resource exists and if commercial development were undertaken, a buffer zone and reinjection could provide powerful tools to mitigate adverse effects of that development on the natural thermal manifestations in Yellowstone.

When modified to reflect specific geologic and geothermal conditions, such tools could also be useful in the protection of other national parks.

This concludes our prepared statement. Dr. Fournier and I are ready to answer any questions you may have.

Senator WALLOP. Thank you, Dr. Christiansen. That was an interesting statement.

Mr. Johnson?

STATEMENT OF WILLIAM L. JOHNSON, DIRECTOR, MINERALS AREA MANAGEMENT, INTERMOUNTAIN REGION, FOREST SERVICE, DEPARTMENT OF AGRICULTURE

Mr. JOHNSON. I am William L. Johnson, Director of Minerals Area Management, Intermountain Region of the Forest Service. Our regional office is in Ogden, Utah.

As Director of Minerals Area Management, my duties are that of a staff specialist to the regional forester in matters pertaining to mineral activities on national forest system lands. My background is that of a geological engineer.

Geothermal leasing on national forest system lands is under the authority of the Geothermal Steam Act of 1970. Section 3 of that act provides that, subject to provisions of section 15, the Secretary of the Interior may issue leases for the development and utilization of geothermal resources in national forest system lands.

Section 15 provides that such lands may be leased with only the consent of and subject to terms and conditions prescribed by the Secretary of Agriculture to insure adequate utilization of the lands for the purposes for which they were withdrawn or acquired. This responsibility of the Secretary of Agriculture is delegated to the Chief of the Forest Service and further delegated to the regional foresters working under the Chief.

The Bureau of Land Management administers the leasing provisions of the Geothermal Steam Act. All geothermal lease applications are filed with the Bureau of Land Management. The Bureau of Land Management transmits all applications involving national forest system lands to the regional office of the Forest Service to determine if the Forest Service consents to leasing and if special terms and conditions are required.

The Forest Service, on behalf of the Secretary of Agriculture, administers and is responsible for the protection and management of national forest system lands. The Forest Service determines through land management planning and the environmental analysis process set forth in the National Environmental Policy Act and the regulations related thereto, whether the Forest Service should consent to geothermal leasing and whether special terms and conditions should be required to protect the surface resources on the national forest system lands.

These processes include coordination with other Federal and State agencies that may have interest in geothermal leasing.

The determinations of the Forest Service are transmitted to the Bureau of Land Management (BLM) which takes final action on lease applications. The BLM may refuse to issue a lease even if the Forest Service has not denied leasing; or the BLM may independently require additional stipulations. Such BLM actions will ordinarily be for issues other than those associated with national forest system lands.

If a lease is issued, it has a primary term of 10 years. The term can be extended in increments of 40 years if commercial production is obtained.

After a lease is issued for national forest system lands and prior to any operations by the lessee, the lessee must submit an operating plan to the U.S. Geological Survey for their approval and the approval of the authorized officer of the Forest Service. The regulations in 30 CFR 270.34 set for the requirements of an operating plan.

Mr. Chairman and members of the committee, I would be pleased to try to respond to questions on geothermal leasing on national forest system lands. I am also familiar with the Island Park geothermal area final environmental impact statement.

Senator WALLOP. Thank you, Mr. Johnson.

Before I turn this to Senator Melcher, I want to make a statement. The statement is that I don't believe that we're here seeking mitigation of potential damage. I think we are here to kind of find some means of satisfying ourselves that there is, you know, potential damage. Because, you know, to mitigate it, I don't think you want that on your record. I sure as hell don't want it on mine. You know, and really what we're talking about is protection in this instance, not mitigation.

And I realize that scientific knowledge and the extent of that may not exist right now. I think that it was implied in your statement, Dr. Christiansen, that we don't know the size, indeed, of the geothermal resource itself and what we might think of it.

The question would be, is there anyone at that table who was comfortable enough about the state of our knowledge right now which would guarantee we wouldn't do damage to the Yellowstone resource?

Dr. HERRMANN. I think what we have to say is that there is no absolute in this case.

Dr. CHRISTIANSEN. I can, obviously, make a statement.

I think it's clear that there is no way one can guarantee it. It depends on what we are talking about guaranteeing, that it will not have any actions. There are very few scientists that can guarantee anything; but I think that we can guarantee that a meteorite will not fall on the

building we are in. I think we could probably proceed with our hearing and not concern ourselves with that kind of probability. I think in the same sense, although——

Senator WALLOP. We can, you know, I'm willing to trust the meteorites; but I'm not willing to trust——

Dr. CHRISTIANSEN. I think what I'm saying is that without proposing that I am advocating one course of action or another, I'm merely trying to say that without trying to claim or appear to claim we can guarantee, I would like to say that scientific knowledge is such that we are not without some idea of what the relationships between this area are and what the kinds of affects could be. What things, let's say, are possible or impossible.

Senator WALLOP. Well, I guess I meant, would it be fair to say that what we're not looking at is mitigation?

Dr. CHRISTIANSEN. Yes; I think perhaps the word mitigation was used in this statement, perhaps, in a sense that was perhaps erroneous. And certainly, it was confusing. I don't think we were intending to imply in response to your statement that there would be some bad things that we could sort of make softer. That's kind of what the word mitigation implies.

I think what was really meant by the use of the word here is that any geothermal production has its effects. And we would propose that those effects could be mitigated in such a manner that they would not propagate into Yellowstone. That would have no affect in Yellowstone.

Senator WALLOP. Does scientific experience indicate that the relatively healthy animal body would, in time, it could revert to a healthy state? Or does history kind of indicate that it doesn't really establish if damage occurs?

Dr. CHRISTIANSEN. Bob should probably talk on that.

Senator WALLOP. Dr. Fournier?

Dr. FOURNIER. This is going to be very highly dependent on the specific things that occur and the time scale that you're dealing with. I was involved with one episode in the park where damage had occurred. And we were able to reverse the damage and put everything to right again.

Senator WALLOP. Would you describe that to us so we get a sense of what——

Dr. FOURNIER. All right. Barrel Spring, which is located in a very narrow canyon right beside the main road linking the northern and southern part of the park, Barrel Spring which had been a very beautiful pool bubbling over, stopped overflowing and became a dirty mud pool. The water level dropped in it 2 or 3 feet.

About the same time the road began to cave into itself with water coming out from underneath the road. This, of course, was very distressful to everybody concerned. So, the Park Service decided that they didn't seem to be able to stop this up by putting more fill dirt in. So, they asked the Bureau of Roads, Bureau of Public Roads to do what they needed to do. They consulted some geologists, and they concluded as a result of that that the crack had formed inside of Barrel Spring and what they would do would be to dig a 10-foot deep trench between the spring and the road and fill that trench with impervious material, which turned out to be a bentonite clay.

The Park Service at the time felt they would like to reestablish the natural condition around that spring. During the road construction a lot of fill material had been placed over the center apron to raise the level of the road. The Park Service decided they wanted that material stripped away and a bridge put over the area and the rest of it put back in natural condition.

I was called in by the Park Service for what you might call a second opinion and to be on hand during the uncovering of the road to tell the roadbuilder when they got to the original surface of the land.

When I arrived on the scene, I did a quick survey of what I thought the situation was. After doing a temperature survey of the road and the study of the water, I concluded that there was not a crack inside of the spring, but there was a second new spring which had opened up underneath the road. And by actually digging this 10-foot trench, they would probably forever stop their ability to actually restore Barrel Spring to what it originally was. This was very distressing to the people who were going to put in the bridge, because the bridge was supposed to go right where I said the spring was.

At any rate, the original plan was started. The material was stripped away and we did find a brand new spring right where I predicted. At which point I insisted that no more work be done on any kind of a trench, or at least not a trench started. Because any disruption over that area would allow water to come up there rather than keeping it in a spring.

So, I designed—well, the next thing was how to deal with this new spring. The usual engineering approach is to pour in cement and stop it up. It turns out that as we uncovered this thing we uncovered two old roads. In each case the road was patched in the same place. When we got down to the center, the reason they had that second spring there was not just because of the earthquake, but in digging the first road they broke the barrier.

So, it was really a man induced thing.

Rather than trying to stop it up and go away, I insisted they build a dam around the area to allow the water to rise to a level higher than the spring. And I believed if you would do that, you would allow the water to flow back to the original channels and the spring would come back.

We did this and it worked perfectly, and we used this dam around the spring to act as an abutment of the bridge.

Senator WALLOP. That's fascinating. John, excuse me for starting. I just want to——

Senator MELCHOR. No, that's fine.

As I understand the final Forest Service EIS which was completed and published in 1980, was appealed. Is that correct?

Mr. JOHNSON. That is correct, Senator.

Senator MELCHER. And it was appealed primarily on the basis that a finding would have to be made by the Secretary of the Interior that no damage would occur within the park to the geothermal features as a result of any leasing in the Island Park area. How big an area did that EIS encompass? In other words, how big a buffer were you talking about?

Mr. JOHNSON. Well, at the time we were talking about a 2-mile buffer strip on the Yellowstone KGRA, which is shown on the wall on a map of the Island Park area. This [pointing] is the Yellowstone (KGRA)

delineated by the Geological Survey. We proposed extending the buffer zone all the way along the park boundary. In the regional forester's decision, there would be an area of deferred leasing until we had better knowledge of the existence of the geothermal resources and had an opportunity to see what affect there might be of any drilling activity that took place in adjacent leased areas.

So, the decision did include an area of deferred leasing.

Senator MELCHER. How big an area?

Mr. JOHNSON. I don't have the exact number in mind. The decision consented to leasing of 37 percent of the area, some 178,000 acres, and 44 percent of the area in a deferred category which would be approximately 215,000 acres.

Senator MELCHER. How far out would that take it or did you identify the areas that would be deferred?

Mr. JOHNSON. Yes, they are defined in our alternative 7.

Senator WALLOP. Are they—can you display them? Can you point to the map?

Mr. JOHNSON. Yes. Do the Senators have a copy of my EIS?

Senator WALLOP. I think we can see.

Mr. JOHNSON. Alternative 7, which was selected by the regional foresters, would have a 2-mile strip coming from the north down through the entire area, here expanding to include the big game migratory routes and—south of the park boundary—an area that is known as a grizzly bear habitat area.

So, there is quite an extensive area here that would be in the deferred category as well as the area up to the State line.

Senator MELCHER. How wide an area is that strip?

Mr. JOHNSON. This zone is 2 miles wide.

Senator MELCHER. All right. Thank you.

Now, Dr. Herrmann, you state in your prepared testimony that there is no definite knowledge that a buffer would protect the geothermal values in the park.

Dr. HERRMANN. That's correct. By that no specific buffer of any size that would allow development within the Island Park area. If we exclude Island Park, of course, that would protect the area.

Senator MELCHER. Pardon me?

Dr. HERRMANN. If we were to bring the buffer all the way out, if development is excluded, then that would absolutely protect the area.

Senator MELCHER. So, whether we're talking about a 2-mile strip, a 6-mile strip, a 15-mile strip, or just picking a figure.

Dr. HERRMANN. That's a political boundary, yes, sir.

Senator MELCHER. Not based on science?

Dr. HERRMANN. No.

Senator MELCHER. Not based on available knowledge?

Dr. HERRMANN. That's not based on geological knowledge.

Senator MELCHER. Dr. Christiansen, you mentioned several times a buffer area and reinjection. A buffer area allows some margin of safety; is that correct?

Dr. CHRISTIANSEN. Yes.

Senator MELCHER. Meaning that it's not known whether it would be safe or not?

Dr. CHRISTIANSEN. Meaning if you're going beyond the area where your immediate knowledge tells you think these areas are isolated from

one to another, but you don't know, so you give yourself some extra margin, suggesting that buffer is a way of addressing that problem.

Senator MELCHER. You referred to reinjection as a tool.

Dr. CHRISTIANSEN. Yes.

Senator MELCHER. Now, in both instances there is no precise knowledge at this time to say that an area at random, the idea is that damage would not occur?

Dr. CHRISTIANSEN. Damage to what, sir?

Senator MELCHER. Geothermal values within the park.

Dr. CHRISTIANSEN. Within the park? All we could say is that it's extremely unlikely that it would occur; but as you said earlier, hardly any knowledge is absolute.

Senator MELCHER. You would monitor fluid pressure in adjacent wells?

Dr. CHRISTIANSEN. Yes.

Senator MELCHER. Is this a means of trying to determine if there might be damage occurring right then?

Dr. CHRISTIANSEN. The purpose of the monitoring is to determine whether pressure gradients are being developed beyond the area of production, beyond the known reservoirs that would be used for production. This is all based upon the hypothesis that this is happening. But if you have development going on and you develop a system of monitoring in wells close to but just beyond the area of the production reservoir, but presumably into the same strata that would be connected with that reservoir and look for pressure changes, that would be what you were monitoring. You would be looking for pressure changes. The only way it would be possible, I believe, to have an affect on the geothermal systems of some distance, let's say many miles, away from the development would be that there would be some pressure interconnection between these areas. And you would be producing the pressure in this one area which would cause water to flow to the area of low pressure and away from the area where you want it in, the national park.

So, by monitoring that pressure, you're looking for an advance indication of a change that would ultimately have an affect some distance up. But it would take a long period of time for it to propagate beyond that point.

Senator MELCHER. So there would be two points, would there not where pressure, if it were lowered, would reduce the activity of the geysers?

Dr. CHRISTIANSEN. Well, that's not even necessarily the specific point. The point of the pressure, of addressing pressure, is that the geysers and the other features of Yellowstone require a kind of system. That is, a very carefully balanced or closely balanced.

Senator MELCHER. It is untouched?

Dr. CHRISTIANSEN. That is untouched, that is right.

Senator MELCHER. So your part about monitoring fluid pressure was to make sure it would not be untouched?

Dr. CHRISTIANSEN. That's right. To be sure that it would remain untouched. That's right.

Senator MELCHER. And second, any lowering of the temperature would have the same affect; would it not?

Dr. CHRISTIANSEN. No.

Senator MELCHER. It would not?

Dr. CHRISTIANSEN. It would not have the same effect. The lowering of the temperature in an area of production would have no affect on the temperature of a nearby area if there was no flow between those two and in order for there to be flow, there would have to be pressure gradients from one to the other.

Senator MELCHER. Both would be harmful if there were any connection?

Dr. CHRISTIANSEN. No. Like I say, if there were no flow, the temperature of the production zone, it would have no effect on Yellowstone.

Senator MELCHER. If there were interconnection?

Dr. CHRISTIANSEN. If there were interconnection, if there were flow, then you would be drawing the water away from Yellowstone area; but the affect would not be related to the temperature change occurring in the production zone. It would be an unrelated affect.

Senator MELCHER. I think Dr. Fournier will tell us if you lower the temperature it would have an adverse effect, too.

Senator WALLOP. Well, if I understood your testimony that it's your opinion that there are two different heat sources, one considerably younger than the other——

Dr. CHRISTIANSEN. Yes; that's correct. And that is based upon, I think, quite adequate data. I think that in itself we are looking at two different sources of heat. And whatever relationship could conceivably exist between the two is that there is nothing you could do to temperatures alone in the Island Park area that could have even a possible if not to guarantee, I'll guarantee that, that it would not have an affect in Yellowstone.

The only way you can have an affect would be to actually divert fluids that would naturally discharge in hydrothermal features in Yellowstone and divert them to areas.

Senator MELCHER. What I'm getting at, Dr. Christiansen, is to understand in my mind what you're going to reinject and why you're reinjecting.

Dr. CHRISTIANSEN. When one speaks of reinjection, what you're doing, the term reinjection means putting the fluids that you have taken out of the ground, run it through a powerplant or whatever and put it back into the ground. And the purpose of doing that is to maintain the reservoir pressure.

Now, you're putting fluids that are now cooler than they were when you took them out. You could even take entirely different water. You could take water from a surface reservoir somewhere and put it into an injection well and use that to maintain pressure.

Senator MELCHER. That's precisely what I thought you meant. You would reinject cool water back in when you remove the hot water.

Dr. CHRISTIANSEN. That's correct.

Senator MELCHER. In this case steam isn't involved. So if there is interconnection, the reinjection is not very much of a tool to maintain the temperature, is it?

Dr. CHRISTIANSEN. Yes, it is. The reason it is—I realize the concept is not very easy to make clear. But the reason it is is because the temperature of the Yellowstone geothermal systems is dependent only on their own heat source.

Now, even if there is a connection between these two, the connection makes no difference unless you actually have flow between them. You have to have fluid moving from one place to another.

You can hypothetically postulate the flow either way. You can make it from Island Park to Yellowstone and vice versa.

Senator MELCHER. Would you feel a drop in the temperature of 2° in the Madison at some point as being an adverse affect?

Dr. CHRISTIANSEN. A temperature drop in the Madison?

Senator MELCHER. Yes, a drop of 2°.

Dr. CHRISTIANSEN. I'm not quite sure. Two degrees of what? Of the rocks or——

Senator MELCHER. Two degrees of the water of the Madison.

Dr. CHRISTIANSEN. Yes. Any change would be an adverse affect.

Senator MELCHER. One degree would be an adverse affect?

Dr. CHRISTIANSEN. Any detectable change would be an adverse affect.

Senator MELCHER. And what would you recommend?

Dr. CHRISTIANSEN. I'm not here to recommend or not recommend.

Senator MELCHER. But you would declare it an adverse affect?

Dr. CHRISTIANSEN. It would definitely be an adverse affect, yes.

Senator MELCHER. All right. Now, Mr. Townsley, how would you view that?

Mr. TOWNSLEY. I would view any changes as an adverse affect.

Senator MELCHER. I certainly would, too.

Now, what I'm going to ask you, Dr. Christiansen, is this: Since you don't know—and no criticism of you for not knowing—how many years are you talking about with regard to a study of possible interconnection? You've been looking at it for 16 years. Dr. Fournier has been working on it for 25 years.

Dr. FOURNIER. Twenty-one years.

Senator MELCHER. All right. Aren't we talking about something that would, to give definite knowledge, probably require a generation or two of very, very careful assessment?

Dr. CHRISTIANSEN. Well, I think we definitely do need, very, very careful assessment.

Senator MELCHER. Without leasing?

Dr. CHRISTIANSEN. Again, that's the kind of question that I simply don't feel competent to——

Senator MELCHER. Now, wait a minute. Somebody's going to have to feel competent. Read what the Secretary says in the memorandum of September 9, 1981, I believe it is. It's signed James Watt, and somebody wrote it for James Watt. And I suspect it was the GS.

Dr. CHRISTIANSEN. I don't know.

Senator MELCHER. Who else would write it?

Dr. CHRISTIANSEN. What I'm saying is that it's obviously appropriate for the Secretary of the Interior to recommend a policy decision. Whether or not leasing should occur is not my competence.

Senator MELCHER. I'm not talking about a policy decision. I'm talking about the scientific knowledge available today to advise the Secretary to carry out his item No. 7, which requires monitoring of the affects the development will have on the hydrologic condition of lands adjacent to national park systems.

Senator WALLOP. In fairness, when we ask the witness to testify, we ask him to testify from a technical and scientific basis. And I don't think they are on the level of decisionmakers and policymakers.

Senator MELCHER. I'm not talking about the policy. I'm talking about the scientific advice that would have to be given to carry that out. And it is not available right now; is it?

Dr. CHRISTIANSEN. You've asked me several different questions, and my mind is on the other one.

Senator MELCHER. Let me just clear it and ask one question. The scientific knowledge is not available with GS or anybody else to say that protection for nationally significant thermal features for Yellowstone is available?

Dr. CHRISTIANSEN. We cannot unequivocally state that development in any particular area will positively have no effect in Yellowstone, that's correct. Dr. Fournier would like to make an additional comment.

Dr. FOURNIER. I would like to say that the information that we don't have available is in regard to what the deep structures are between Yellowstone and Island Park. We do not know what the degree of permeability is between those two features. That's the unknown thing.

I think that members of the panel would say that if certain conditions were met, then we could guarantee that nothing would happen. The problem is if those conditions were met—and we can't guarantee that those conditions would be met—the main condition that if they could be guaranteed that there would be no change in the pressure of the groundwater system in the area of exploitation, then there would be no affect on the geysers in Yellowstone Park.

Senator MELCHER. And my point is this, then. It would probably take, depending on the money and the staff available, it would probably take a number of years to regain that information, would it not?

Dr. FOURNIER. No, sir. The information is not whether or what the rock types are like between the two. The information is whether or not you can maintain the pressures in a reservoir where exploitation takes place. This is a matter of how much water pressure is in the system and how much the people are doing, pumping, are induced to maintain that pumping pressure.

Senator MELCHER. How many wells are you talking about?

Dr. FOURNIER. This would depend on how much water is taken out and at what rate and at what depth and how well your injection well was able to take the water.

Senator MELCHER. Then you're not recommending that GS pursue a program to gain this information prior to leasing?

Dr. FOURNIER. I am definitely not recommending that GS pursue a policy of gaining this information prior to——

Senator MELCHER. Now, Mr. Townsley, based on this and speaking for yourself as Superintendent, do you have some fear that leasing might cause some adverse things? Not from the standpoint of what a policy is to the Department of Interior, but what your own personal knowledge is as the park superintendent?

Mr. TOWNSLEY. I think I expressed that once before to you at a hearing, and I would have to——

Senator MELCHER. I just asked you whether you've changed.

Mr. TOWNSLEY. I have not changed that, sir.

Senator MELCHER. Well, I haven't either.

If there are not going to be any findings made before leasing, then I will definitely oppose it. And the monitoring, as the leasing takes shape and the commercial development takes shape, is not satisfactory to me. Nor do I believe it to be satisfactory to the American people, because you simply can't—I don't like to use the word guarantee, but I'll use assure—that there won't be a change in the two significant features you have mentioned, a change in hydrothermal pressure and a change in the temperature.

Thank you very much.

Senator WALLOP. How does—how would this kind of development differ from that development to the extent that you know what might be proposed? And I guess nobody really has a determined project. But assuming an economically feasible development, you would know better than I would what that might be in terms of numbers of wells and other things. How would it differ from the structures at Wairakei and Waiotopu and how would, you know, is there anything that we can learn from what happened there that might happen here?

Dr. CHRISTIANSEN. Yes, indeed. There are a number of things that we can learn from the experience there. And in fact, a great deal of our understanding of how aspects of the subsurface system works does come from that area. Because they do have a lot of subsurface information.

Certainly one of the things we learned from that experience is that it is necessary to have reinjection. They did not reinject. Also, they did deliberately undertake to do geothermal development in, not near, but in a major geyser area. This would not amount to having geothermal activities in the upper geyser system in Yellowstone. Certainly from the point of view of the engineering lessons we have learned from them, very useful indeed.

Also, the fact that they did have an anticipated area as far away at the 2½ to 3 miles. Clearly that is a lesson for us that we should give ourselves more margin than we sometimes think we might need. Just what that margin is to be is a matter that should be discussed on the basis of all the available and applicable scientific knowledge.

Senator WALLOP. What is the significance of the statement in the Forest Service EIS with regard to Waiotopu where they said that drilling 9 to 12 miles may have induced a chemical change or interference. Is there any conclusion in what the chemical change would signify in terms of potential damage?

Dr. FRONTIER. Chemical change, you can have a mixing of two waters that were not mixed before. And this can occur because of change of pressure at depth. Actually, that kind of mixing is done once a year at North Basin because of the pressure changes. The chemical change can also take place if you change the amount of gas that is entering the system. Specifically, if you have more carbon dioxide in the system you end up with high bicarbonate in the water. Or if you lower the water table a little bit, you may have a little bit of acidity developing. I don't recall precisely what the nature of that chemical change was.

The only problem in all of this was they didn't have the baseline data to know the natural variation in hot springs composition at this 12 miles to say whether or not it was an induced finding.

So, it was a change in chemistry noted, but changes in chemistry are the norm rather than the exception. So, you really can't stay definitely whether it was due to that development or whether it was not due to the development.

Senator WALLOP. What possible consequences could a chemical change have? I mean, would they be serious? Could they be serious?

Dr. FOURNIER. They could be serious only if the water table drops drastically. If you have a situation where you have spring flowing and then those springs are converted from alkaline chloride type to an acid sulfate type, the water table drops and you have rain water up above, that rain water can be acid and cause complete disintegration of any type of material you add to the surface.

Other than that, these chemical changes——

Senator WALLOP. Can that take naturally, though?

Dr. FOURNIER. Yes. Let me back up. If the chemical change is such that you are drastically changing the carbon dioxide, you can induce calcium carbonate. And that could clog up your channels of movement. So, that could happen.

Senator WALLOP. Could that run in either direction?

Dr. FOURNIER. It could run in either direction.

Senator WALLOP. I don't know the geology of the area and——

Dr. FOURNIER. Well, the connection, if there is one, between Island Park and Yellowstone, from the geology, from geophysics and from what we know about the temperature distribution of the rock, there should be a major temperature drain between Yellowstone and Island Park. In response to that temperature gradient, there should be silica that comes down as a water coolant. It is a very important process. It has actually sealed up several of the research holes we have drilled in Yellowstone naturally.

So, I would expect that if there is a hot spring system in—well, we know there is a hot spring system in Yellowstone. I would expect that would be insulated in a silica. And this would stop water flow. Unless you have some way of continuing to take that material, water will continue to flow. Now, in those regions of the park we have a lot of seismic activity. Water gets through. I have to know that there is almost no seismic activity between Yellowstone and the Island Park area.

Senator WALLOP. There isn't? Are either of you familiar with Dr. Diam's studies on the radio nuclei?

Dr. CHRISTIANSEN. Yes; I am familiar with the studies.

Senator WALLOP. Does that—do those studies indicate a further need for study and an increase in baseline data?

Dr. CHRISTIANSEN. I think they are a very interesting set of data, and they do indeed raise the reasonability of getting more baseline data in these areas, yes. I think it would be very useful to do.

I think they should not be taken as indicating that there is any hazard associated with these radio nucleis that is outside the immediate area where they are determined, the area the study was made. You have a somewhat higher content of uranium, but only slight.

So, it's a difference nf, say, 6 or 7 parts per million rather than 5 or 6. But because of the very special features there, the specific nature of the warm ground areas where he made his study, there happens to be a high concentration of those in the ecological community. There is no

evidence, there is no reason to think—we do have a great deal of additional evidence, information in the hydrochrome system in Yellowstone. And the USGS did support the specifics of that. And there is no indication that there is any problem associated with that as far as environmental or health problems in the waters.

Senator WALLOP. Now, the last paragraph of that study, I would ask that we just put this series of conclusions into the record so that we might—perhaps we could submit those to you and make a comment from your professional standpoint.

Dr. CHRISTIANSEN. It might be useful at this point, and this is something that Bob Fournier pointed out to me earlier, too. That the study we did make of radio nuclei distribution indicates that the higher the temperature of the water the lower the radioactive nuclei content. So, actually, in terms of the areas of production possibility, you would probably be less likely to have a serious affect than you are in the natural cooler waters.

Senator WALLOP. I have a couple of little things.

In your statement, Dr. Christiansen, you say that if the position and size of such a hypothetical resources were known, delineation of a buffer zone for Yellowstone could be attempted on a different basis. How would we get to that point?

Dr. CHRISTIANSEN. I think the way in what Bob said, he would be recommending the USGS did that. What he's referring to is that's the kind of information that can only come back from drilling and from following the course of drilling and production and doing parallel studies. It's the kind of thing you learn in increments. And the data accumulates in increments, as you go along.

So, in order to go ahead and do that in that nature, in a specific sense, specifically how you would treat this problem, you would have to find out what kind of a reservoir it is, how it would be produced, what kind of well, well spacing required, technical things of that sort. Each step of the way would give you the information needed in order to design those things needed to correctly monitor that situation.

However, there are some things that can be done in advance. I don't think he implied there is nothing you can do in advance. There are studies that we could undertake and would hope to at some point with funding available to do that; but that would give you useful information on just what kind of structural framework exists in the area and how it controls those parts of the hydrologic region.

Senator WALLOP. Just as a scientist, now, would you recommend that those things take place contemporaneously as any project were to be authorized in that area and that, you know, that based on that information there would be no-go steps all along?

Dr. CHRISTIANSEN. Yes. From the point of view of a scientist, I would say that's the only acceptable way we would consider any kind of development in that region, would be on that sort of a basis, that there would be a step-by-step set of stipulations. And——

Senator WALLOP. Could you supply for the committee a rough outline of what such a monitoring system might look like?

Dr. CHRISTIANSEN. In a very general way, of course.

Senator WALLOP. I realize that, because it's hypothetical, going back to your statement that it's hypothetical in the first place. But it would seem to me two things; one, I guess if anybody were to make such an

investment, they would have to be remarkably high rollers to commit that amount of capital on the basis of there being a no-go decision at any point in time. But yet your statement, I think, is probably scientifically sound, but being the only basis upon which it could be really safely undertaken.

Dr. CHRISTIANSEN. Well, our objective, we are assuring that we protect or preserve the system at Yellowstone, as I say, from a strictly scientific view. I would feel that way, yes.

Senator WALLOP. John Townsley, what is the status of funding for the geothermal research and geological studies in the park now?

Mr. TOWNSLEY. I don't have the action that may have been pursued in Congress; but I would be pleased to provide those for you. We are not doing some research funding through the USGS. I think at one time there was some 13 or 15 seismic locations that were giving you continuous data. And I think there are only two of these functioning now. We have not been able, out of operating moneys, to provide sufficient funds to continue that work.

That is a bit different than some of the things that you are talking about here; however, as this process has gone along, there have been things in the service about trying to provide money to go to the USGS for research. And we would be pleased to provide that for the record.

Senator WALLOP. We'll have some questions that we may wish to submit to you later.

Dr. HERRMANN. I can provide the status. There are no Park Service funds now programed for geothermal research in Yellowstone. I checked into that before I came.

Senator WALLOP. Thank you. Is it a safe generality to say that the basic nature of the threats, to the extent there are threats that exist, are hydrologic more than the nature and the extent of the heat source itself?

Dr. CHRISTIANSEN. That is quite correct; yes.

Senator WALLOP. Well, thank you, gentlemen. Thank you very much. We all appreciate your effort in coming here and your willingness to provide us with this information.

[Subsequent to the hearing the subcommittee received the following information:]

91-917 O - 82 - 3

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

324 25th Street
Ogden, UT 84401

1982 JAN -7 PM 3:48

2820

DEC 23 1981

Honorable Malcolm Wallop
2201 Federal Building
Casper, WY 82601

Dear Senator Wallop:

This is in reference to the December 12 Subcommittee meeting in Casper, Wyoming, on public lands and reserved water. At the close of the meeting, Mr. William Johnson was requested to furnish the Subcommittee with a map depicting the oil and gas lease offers pending within the Island Park Geothermal Area, Targhee National Forest, Idaho.

The enclosed map, together with a lease tabulation sheet, constitutes our record of pending leases as of December 11, 1981. If we can be of further assistance to the Subcommittee, please let us know.

Sincerely,

for L. KENT MAYS, JR.
Deputy Regional Forester
Resources

Enclosures (2)

(Committee note.--The map has been retained in subcommittee files.)

Oil and Gas Lease Offers in Island Park
Geothermal Area - Idaho

Lease No	Applicant	Date Filed	T., R.	All or Portions of Sections	Total Acres In App
I-12714	W. V. Moore	10/76	10N.43E.	25-28	2,560.00
I-12715	W. V. Moore	10/76	11N.41E.	13,22-24	2,560.00
I-12716	W. V. Moore	11/76	11N.41E.	25-27,35	2,560.00
I-12720	W. V. Moore	10/76	12N.40E.	1,2,11,12	2,251.00
I-12721	W. V. Moore	10/76	11N.41E.	5-8	2,555.80
I-12722	W. V. Moore	10/76	11N.41E.	3,4,9,10	2,566.48
I-12723	W. V. Moore	10/76	11N.41E.	1,2,11,12	2,563.28
I-12726	W. V. Moore	10/76	11N.41E.	29,30,32,34	1,000.00
I-12728	W. V. Moore	10/76	10N.43E.	33-35	1,920.00
I-12730	W. V. Moore	?	10N.42E.	30-34	2,291.43
I-12731	W. V. Moore	?	11N.43E.	5-7	1,910.68
I-12732	W. V. Moore	10/76	11N.42E.	18,19	1,269.64
I-12733	W. V. Moore	10/76	11N.42E.	30,31	1,272.52
I-12734	W. V. Moore	10/76	9N.44E.	1,2,11,12	2,563.32
I-12735	W. V. Moore	10/76	9N.44E.	3,4,9,10	2,527.31
I-12736	W. V. Moore	10/76	10N.43E.	29-32	2,566.62
I-12737	W. V. Moore	10/76	9N.43E.	4-7	2,137.38
I-12738	W. V. Moore	10/76	9N.43E.	8-10,21	1,040.00
I-12739	W. V. Moore	10/76	9N.43E.	1-3	1,932.45
I-12740	W. V. Moore	10/76	10N.42E.	17-20	2,524.09
I-12741	W. V. Moore	10/76	10N.42E.	5-8	2,559.64
I-12743	W. V. Moore	10/76	10N.44E.	33-35	1,920.00
I-12744	W. V. Moore	10/76	10N.44E.	25-28	2,560.00
I-13237	Supron Energy	?	10N.42E.	1,2,11,12	2,571.28
I-13238	Supron Energy	10/76	10N.42E.	24,25,35,26	2,568.21
I-13239	Supron Energy	10/76	10N.42E.	13,26,27	1,920.00
I-13240	Supron Energy	10/76	10N.42E.	14,15,22,23	2,560.00
I-13241	Supron Energy	10/76	10N.42E.	16,21,28,29	2,560.00
I-13242	Supron Energy	10/76	10N.42E.	3,4,9,10	2,564.44
I-13245	Supron Energy	10/76	12N.41E.	22,23,26,27	2,560.00
I-13246	Supron Energy	10/76	12N.41E.	20,21,28,29	2,560.00
I-13247	Supron Energy	?	12N.41E.	8,9,16,17	2,560.00
I-13248	Supron Energy	?	12N.41E.	32-35	2,489.52
I-13249	Supron Energy	?	12N.41E.	24,25,36	1,915.44
I-13250	Supron Energy	?	12N.41E.	4-7	2,151.62
I-13251	Supron Energy	?	12N.41E.	18,19,30,31	2,528.18
I-13252	Supron Energy	?	11N.42E.	8,17,20,29	2,560.00
I-13253	Supron Energy	?	11N.42E.	15,21,22	1,920.00
I-13254	Supron Energy	?	11N.42E.	3,4,9,10	2,557.88
I-13255	Supron Energy	?	11N.42E.	27,32-34	2,560.00
I-13256	Supron Energy	?	11N.42E.	26,35	1,280.00
I-13258	Supron Energy	?	11N.42E.	28	640.00
I-13388	Ed Pendleton	?	8N.45E.	1,2,34,35	2,435.88

I-13459	Ed Pendleton	?	13N.43E.	5,6,7,18	2,255.47
I-13460	Ed Pendleton	6/77	12N.43E.	22,26,27,34	2,560.00
I-13462	Ed Pendleton	6/77	12N.43E.	17-20	2,530.64
I-13464	Ed Pendleton	6/77	12N.41E.	3,10,14,15	2,415.00
I-13466	Ed Pendleton	6/77	12N.43E.	5-8	1,004.00
I-13457	Ed Pendleton	6/77	8N.45E.	3-6,9	2,395.29
I-13602	Ed Pendleton	7/77	9N.43E.	1,10,12	650.00
I-13603	Ed Pendleton	7/77	11N.43E.	20-22	1,920.00
I-13604	Ed Pendleton	7/77	11N.43E.	14,15,23	1,600.00
I-13605	Ed Pendleton	7/77	9N.43E.	34-36	1,920.00
I-13606	Ed Pendleton	7/77	9N.45E.	26-28	1,600.00
I-13617	Delores Dever	7/77	8N.45E.	10,15,33	649.15
I-13657	Ed Pendleton	?	12N.42E.	13,32	1,040.00
I-13658	Ed Pendleton	?	13N.42E.	7,24,35	1,034.80
I-14091	Edward A. Meany	10/77	14N.43E.	22-26	2,360.00
I-14092	Edward A. Meany	10/77	14N.43E.	27,28,34,35	2,313.60
I-14095	Edward A. Meany	10/77	14N.44E.	1,2,11,14	2,556.00
I-14096	Edward A. Meany	10/77	14N.44E.	3,4,10,15	2,561.00
I-14097	Edward A. Meany	10/77	14N.44E.	13,14,23,24	2,560.00
I-14098	Edward A. Meany	10/77	14N.44E.	25,26,35,36	2,560.00
I-14099	Edward A. Meany	10/77	14N.44E.	21,22,27,28	2,560.00
I-14100	Edward A. Meany	10/77	14N.44E.	5,17,20,29,30	2,117.00
I-14101	Edward A. Meany	?	14N.44E.	31-34	2,171.89
I-14102	Edward A. Meany	10/77	13N.44E.	1-4	2,323.23
I-14103	Edward A. Meany	10/77	13N.44E.	5-9	2,389.73
I-14104	Edward A. Meany	10/77	13N.44E.	10-13	2,240.00
I-14105	Edward A. Meany	10/77	13N.44E.	14,15,17,18	2,557.16
I-14106	Edward A. Meany	10/77	13N.43E.	8,9,15,17	2,085.61
I-14107	Edward A. Meany	10/77	15N.44E.	19-21	1,920.00
I-14108	Edward A. Meany	10/77	15N.44E.	28-30	1,920.00
I-14109	Edward A. Meany	10/77	15N.44E.	31-33	1,560.15
I-14110	Edward A. Meany	10/77	13N.42E.	25-28,30,31	901.19
I-14111	Edward A. Meany	10/77	13N.43E.	8,17,21-23	2,451.91
I-14112	Edward A. Meany	10/77	13N.43E.	31-34	2,041.54
I-14113	Edward A. Meany	10/77	13N.44E.	22-25	2,560.00
I-14114	Edward A. Meany	10/77	13N.44E.	33-35	1,920.00
I-14115	Edward A. Meany	10/77	13N.44E.	26-29	2,551.30
I-14116	Edward A. Meany	10/77	13N.44E.	8,19-21,31	2,514.60
I-14118	Edward A. Meany	10/77	13N.44E.	30,32	919.28
I-14121	Edward A. Meany	10/77	13N.42E.	33-35	640.00
I-14157	Edward A. Meany	10/77	14N.44E.	12	640.00
I-14186	Cabot Corp.	11/77	10N.43E.	1,2,11,12	2,556.02
I-14187	Cabot Corp.	11/77	10N.43E.	3,4,9,10	2,554.40
I-14188	Cabot Corp.	11/77	10N.43E.	5-8	2,554.64
I-14189	Cabot Corp.	11/77	10N.43E.	17-20	2,242.14
I-14190	Cabot Corp.	11/77	10N.43E.	13,14,23,24	2,540.00
I-14191	Cabot Corp.	11/77	10N.43E.	20-22	1,600.00
I-14192	Cabot Corp.	11/77	11N.43E.	1,2,11,12	2,560.00
I-14193	Cabot Corp.	11/77	11N.43E.	3,4,9,10	2,560.00
I-14194	Cabot Corp.	11/77	11N.43E.	5-8	2,271.82

I-14195	Cabot Corp.	11/77	11N.43E.	17-19,30	2,534.85
I-14196	Cabot Corp.	11/77	11N.43E.	29-32	2,074.87
I-14197	Cabot Corp.	11/77	11N.43E.	27,28,33,34	2,431.23
I-14198	Cabot Corp.	11/77	11N.43E.	25,26,34,35	2,099.29
I-14199	Cabot Corp.	11/77	11N.43E.	13,23,24	1,600.00
I-15964	D.M. Notestine	8/79	10N.43E.	15	640.00
I-16638	Laura Spangler	6/80	12N.43E.	10-15,23,24, 29-33	7,520.00
I-16545	Laura Spangler	6/80	13N.42E.	2-6,11-15,23, 26-30	6,054.90
I-16569	Laura Spangler	6/80	13N.43E.	1-4,10-14,19, 20,34,35	7,705.00
I-16076	Edward Meany	10/79	13N.43E.	24-28	2,191.40
I-16077	Edward Meany	10/79	13N.43E.	29,30	788.92
I-16606	Laura Spangler	6/80	12N.44E.	1-3,10-15,20, 21,27,28,34	7,513.16
I-17084	Thomas Hewitt	12/80	8N.46E.	7,19	1,280.00
I-17071	Thomas Hewitt	12/80	12N.44E.	4-6,8,9,17-20	2,491.50
I-17070	Thomas Hewitt	12/80	10N.44E.	22-24	1,920.00
I-17067	Thomas Hewitt	12/80	11N.42E.	1,2,11,14,23	2,478.52
I-17075	Thomas Hewitt	12/80	14N.45E.	19,30	1,280.00
I-17076	Thomas Hewitt	12/80	13N.45E.	18,19	1,281.19
I-17077	Thomas Hewitt	12/80	9N.45E.	25,28,33	1,598.85
I-17079	Thomas Hewitt	12/80	11N.42E.	1,12,13,24,25	2,193.65
I-17082	Thomas Hewitt	12/80	12N.43E.	19-21,25,28	2,560.00
I-17368	Love Oil Co.	3/81	8N.46E.	5,6,8,17,18, 20,29,30,32	4,324.17
I-17367	Love Oil Co.	3/81	9N.46E.	5-8,17,18,20, 29-32	4,332.73
I-17457	Love Oil Co.	3/81	9N.45E.	1-11,15-18	8,572.05
I-17456	Love Oil Co.	3/81	9N.45E.	12-14,19-24, 29-32	8,260.90
I-17522	C.E. Harvey	4/81	11N.45E.	17-20,29-32	9,600.00
I-17521	C.E. Harvey	4/81	11N.44E.	15,16,19-22, 27-35	9,600.80
I-17520	C.E. Harvey	4/81	12N.44E.	22-36	9,600.00
I-17519	C.E. Harvey	4/81	12N.45E.	18-21,28-33	8,960.00
I-17518	C.E. Harvey	4/81	11N.44E.	1-12,17,18	8,960.00
I-17523	C.E. Harvey	4/81	12N.44E.	1,12-14	2,560.00
I-17524	C.E. Harvey	4/81	14N.45E. 13N.45E.	32,33, 3-5,8-10,15-17, 20-22,27	9,600.00
I-17525	C. E. Harvey	4/81	13N.45E. 12N.45E.	28-34 4-9,16,17	9,600.00
I-17788	Thomas Hewitt	6/81	12N.43E.	1-4,9	3,026.24

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

January 25, 1982

Honorable James A. McClure
Chairman, Committee on Energy
and Natural Resources
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

Enclosed please find additional information requested at the field hearing before the Senate Energy and Natural Resources Committee, Subcommittee on Public Lands and Reserved Water, on December 12, 1981, on protection of geothermal resources in Yellowstone National Park.

The enclosed information has been prepared for insertion in the record. Enclosure one contains comments on a report on radionuclides prepared in 1979 Diem and Kennington. Enclosure two describes a possible scheme for monitoring reservoir pressure associated with the development of a geothermal field.

Thank you for the opportunity to provide this material to the Committee.

Sincerely,

Theodore J. Garrish
Legislative Counsel

cc:
Al Astrin

Enclosure 1

Comments on Report by Deim and Kennington on Radionuclides

The 1979 report by Diem and Kennington, "Rhyolite radionuclide uptake by selected plant species and pocket gophers in Yellowstone National Park", calls attention to the well known fact that rocks of rhyolitic composition usually contain greater concentrations of radioactive elements than most other rocks. In regard to the bearing that this fact may have on the levels of radioactivity in geothermal waters flowing through rhyolitic rocks, the USGS Geothermal Research Program funded a study of radionuclides in geothermal waters of the western United States, including Yellowstone National Park. The study was carried out by Professors J. K. Osmond and J. B. Cowart of Florida State University in 1975-77. Their results show that acid geothermal waters contain relatively high concentrations of radionuclides. Very little acid geothermal water is discharged at Yellowstone and adjacent areas, and furthermore, such acid waters generally are not of interest for geothermal development because they are highly corrosive. The results also show that radionuclide concentrations in weakly acid to alkaline geothermal waters are relatively low compared with both acid thermal waters and non-thermal waters. Thus, in general, the radionuclide content of developed geothermal waters can be anticipated to be the lowest for all types of water of a particular region.

Enclosure 2

A Possible Scheme of Monitoring of Reservoir Pressure Associated with the Development of a Geothermal Field

A monitoring program should be initiated when sustained, long-term flow of fluids is begun from wells in a geothermal field. The exact number and location of monitoring wells would depend on the number and position of wells within the field being developed from which fluids are being produced. The following scheme might apply to a development of 5 to 10 production wells (including reinjection wells). More production wells imply the need for more monitoring wells.

One deep monitoring well would be recommended outside the production field, but much closer to it than to the natural thermal manifestations of concern. This well would have to tap the geothermal reservoir under production, so that a hydrologic connection is assured. Thus, in general, the well would be of comparable depth to the production wells. A second monitoring well should be positioned within the production field to provide a record of pressure in the exploited reservoir against which the measurements outside the field could be compared. (Either a shut in or unsuccessful production well could be used for this purpose.) The cost of drilling a deep well depends on a number of factors that cannot be analyzed here, but the "average" cost of a "typical" deep well might be on the order of $100 to $150 per foot. Thus, for example, a 10,000 foot well might cost between $1,000,000 and $1,500,000. Continuing fixed costs would include support for someone to make periodic measurements of reservoir pressure and to analyze and interpret these data, and might amount to between $20,000 to $30,000 per year, as a base figure. With an increasing number of monitoring wells, the continuing fixed costs would also increase somewhat.

A reasonable scheme for implementing the above monitoring program would include the following: (1) Allow drilling of deep exploration wells and short term flow testing of such wells for periods up to several days or somewhat longer to permit industry to establish the existence or lack of a commercial resource. (2) Establish both reinjection and monitoring wells before any longer-term fluid flow from production wells is allowed.

Senator WALLOP. The next panel is Henry Heasler, principal investigator for the Wyoming geothermal resource assessment project group; Gordon Bloomquist, geothermal specialist, Washington State Energy Office; Leah Street-Martin, geothermal program specialist, Idaho Department of Water Resources.

Dr. Heasler?

Dr. HEASLER. I wish to thank the members of the subcommittee to allow me to testify.

Originally when I was contacted, I was asked also to talk about other national parklands administered in Wyoming. I can keep my comments to that of Yellowstone or cover the others.

Senator WALLOP. We'll have your whole statement. And anything that you may care to add parenthetically that is in that statement with regard to other parks is fine; but why don't we generally focus on the park issue.

Dr. HEASLER. OK. On the park issue, I have given copies of my entire testimony to the subcommittee, and that refers to the entire State of Wyoming.

Senator WALLOP. I haven't had a chance to preview it. Do you look at all at the Hot Springs State Park?

Dr. HEASLER. That's a very interesting question. If you want me to address that now, I can, or else go through the Yellowstone or do you prefer it——

Senator WALLOP. Why don't you do both, because I know I am going to get a lot of questions about it, anyway.

STATEMENT OF DR. HENRY P. HEASLER, DEPARTMENT OF GEOLOGY AND GEOPHYSICS, UNIVERSITY OF WYOMING, LARAMIE, WYO.

Dr. HEASLER. What data we have about Yellowstone, which is somewhat sparse, and then I'll explain what we know about the Thermopolis system at the Hot Springs State Park.

I'm Henry P. Heasler, on staff at the University of Wyoming Department of Geology and Geophysics.

The Department of Geology and Geophysics at the University of Wyoming is investigating the geothermal potential of Wyoming and bordering areas. This research is supported by the U.S. Department of Energy with earlier funding from the National Science Foundation. Department of Energy funding began in December of 1978 with total funding from the DOE amounting to approximately $600,000.

I personally have been involved in geothermal research in Wyoming for about the last 6 years.

This report is going to present a brief summary of current research results. It is hoped that the information presented herein will be of use to members of the subcommittee in understanding the types of geothermal systems in Wyoming and potential benefits in how these systems relate to National Park Service administered lands.

And the oral testimony will cover how the information relates to Yellowstone National Park.

I guess I can make this part of it very short by saying our study was to focus everywhere exclusive of Yellowstone National Park. Basically, Yellowstone National Park, as testified by Bob Christian-

sen and others, is a volcanic plutonic system. This basically is one that results from localized heat sources where molten or partially molten rock is close to the Earth. The more recent and widespread volcanic activity, the more likely a high temperature geothermal resource will be present. In Wyoming, Yellowstone National Park is the only confirmed high temperature geothermal system of this kind. Our only thermal data for the area around Yellowstone comes from the east and northeast of the park in the Shoshone National Forest.

Basically, our data indicates that the high thermal anomaly in the park is caused by near surface heat sources that do not extend to the east or northeast. And I have various other references in my report which agrees with these conclusions.

The unpublished temperature and heat flow determinations collected by our group confirms this interpreation.

Basically, what I'm saying there is that our data to the east of Yellowstone National Park shows no evidence for high temperature geothermal systems.

OK. That basically is my testimony on Yellowstone. Other areas in the State are covered in the written testimony.

Hot Springs State Park is not in any way connected with Yellowstone. It's basically a type of geothermal system where the water is hot just due to the normal increase in temperature with depth. In other words, in Wyoming the temperature increases about 18° F. for every 1,000 feet you get lower. If you drilled a hole that was 10,000 feet deep, the temperature would be 180° F.

In Thermopolis the plunge of the rocks are such that cold groundwater, rain water, enters aquifers or rock-bearing units like the Madison Limestone. The rocks are downwashed, and it obtains a depth of 7,000 feet where it feeds to about 150° F. And those rocks due to the geology are brought quickly to the surface where the heat is brought to the surface and comes out as a hot spring. There is no magma or volcanic activity associated with the Hot Springs State Park. Even though they are within 100 miles, they are totally different types of geothermal systems that bear no interconnection at all.

Senator WALLOP. That water goes up considerably faster than it goes down?

Dr. HEASLER. That's part of it. Also, it's going down over, say a period of 15 miles. It's a very gradually slope off of the Owl Creek Mountain, whereas the structure that brings it up is very sharp and occurs over a 1-mile area. So, the plumbing is right such that, due to a normal hydrologic flow, that the water comes quickly close to the surface, and in this case close to the surface at the springs there at Hot Springs State Park.

Senator WALLOP. You have, as well, I gather, with you the statement of Dr. Marrs?

Dr. HEASLER. I have the report written by Dr. Marrs and Dr. Levinson, yes.

Senator WALLOP. We will submit that for the record. We will put that in. And I thank you for that.

[The prepared statement of Dr. Heasler and report follow:]

A SUMMARY OF GEOTHERMAL POTENTIAL IN WYOMING

by

Henry P. Heasler
Department of Geology and Geophysics
University of Wyoming
Laramie, Wyoming

Prepared for
The Senate Public Lands and Reserve Water Subcommittee

December 12, 1981
Casper, Wyoming

INTRODUCTION

The Department of Geology and Geophysics at the University of Wyoming is investigating the geothermal potential of Wyoming and bordering areas. This research is supported by the United States Department of Energy with earlier funding from the National Science Foundation. Department of Energy funding began in December of 1978 with total funding from the D.O.E. amounting to $588,984.00.

This report presents a brief summary of current research results. It is hoped that the information presented herein will be of use to members of the Subcommittee in understanding the types of geothermal systems in Wyoming and potential benefits. The report is divided into sections on research methods, the characterization of the resources in Wyoming, specific areas with potential low-temperature resources, and present and planned geothermal uses. Data on geothermal uses in Wyoming are from the Wyoming Geothermal Commercialization Office locatd at the University of Wyoming.

Substantial portions of this report have been taken from two earlier reports (see Decker et al., 1980b and Heasler, 1981). The conclusions and data presented in those earlier reports are revised and updated for inclusion in this report.

RESEARCH METHODS

Geothermal research has focused on detailed studies of low-temperature (less than 90°C (194°F)) resource areas, compilations of regional geothermal data, and syntheses of pertinent geology and geophysics. Compilations of geothermal data include oil well bottom hole temperatures which are used to construct thermal gradient and contour maps, field measurements of temperature profiles in drill holes, and the measurement and computation of the amount of heat flowing through specific rock layers. As part of the heat flow computation, laboratory measurements of rock thermal conductivity are made and interpretated with field measured temperature data. Heat flow values are then used to model the type of geothermal system in an area and predict its maximum temperature.

Throughout the text, temperatures are given in °F or °C (°F = 1.8°C + 32), geothermal gradients are given in °F/1000 feet = 1.82 °C/km) and depths are reported in feet or meters (1 foot = .305 meters). The flow of heat within the earth is given in heat flow units abbreviated HFU where 1 HFU = 1 X 10^{-6} calories/cm^2 - sec = 41.8 milliwatts/m^2.

GEOTHERMAL CHARACTERIZATION OF WYOMING

Geothermal systems in Wyoming can be classified into three main catagories as volcanic-plutonic systems, deep sedimentary basin systems, or shallow to moderate depth hydrothermal convective systems. Each of these three systems can be further subdivided into high temperature (greater than 150°C (302°F)), moderate temperature (90-150°C (194-302°F)), or low temperature (less than 90°C (194°F)) resources.

Volcanic-Plutonic Systems

Volcanic-plutonic geothermal systems result from localized heat sources where molten rock is close to the surface of the Earth. The more recent and widespread the volcanic activity the more likely a high temperature geothermal resource will be present. In Wyoming, Yellowstone National Park is the only confirmed high temperature geothermal system of this kind. A research drill hole by the U. S. Geological Survey encountered a temperature of 237°C (458°F) at a depth of 330 meters (1,080 feet) in the Norris Geyser Basin of Yellowstone (White et al., 1975). The Yellowstone National Park area has more than 10,000 identified hot springs, geysers, and steam vents which are surface manifestations of the large amount of heat energy present.

Thermal data to the east and northeast of the Park indicate that the high thermal anomaly in the Park is caused by near surface heat sources that do not extend to the east or northeast (Blackwell, 1969; Decker, et al., 1980a; Morgan et al., 1977). Unpublished temperature and heat flow determinations collected by our group confirms this interpretation.

Two other volcanic-plutonic systems in Wyoming are young enough to possibly contain some useable geothermal resources. These two areas are portions of the Black Hills in northwestern Wyoming and the Leucite Hills located in the northern portion of the Rock Springs Uplift in southeastern Wyoming (see Figure 1). Evidence for a possible thermal anomaly in the Black Hills is based upon heat flow determinations from three drill holes (see Blackwell, 1969; Decker et al., 1980a, and Sass et al., 1971). However, as Sass et al. (1971) propose, it may be premature to suggest a regional thermal pattern for the Black Hills area.

In the Leucite Hills area no evidence has been found to indicate the presence of a shallow geothermal resource. Thermal gradient and heat flow determinations in the are are considered normal and thermal modeling of the area suggests that any volcanic heat has already dissipated.

Deep Sedimentary Basins

Deep sedimentary basins constitute the second type of geothermal system present in Wyoming. Moderate temperature waters (90°-150°C (194-302°F)) are found in the deeper portions of most of Wyoming's major structural basins. These basins include the Bighorn Basin, Wind River Basin, Green River Basin, Powder River Basin, Great Divide Basin, and Washakie Basin (see Figure 1). Hot water is found in these basins due to the Earth's normal increase in temperature with increasing depth (the increase in temperature with depth is called the geothermal gradient). Certain water-bearing rock units in these basins are folded deep enough (usually over 3 km (10,000 feet)) such that the surrounding rocks heat the water.

This type of geothermal system exists only in the deep central portions of the basins where drilling for a moderate temperature geothermal resource is uneconomical. However, since many of the water bearing rocks such as the Madison Limestone, Tensleep Sandstone, or Mesaverde Formation also sometimes contain oil, deep holes are drilled into these rock units. If hydrocarbons are not encountered, the drill holes are plugged even if hot waters are found. A streamlining of regulations that would easily allow the transferring of these oil exploration holes to municipalities or individuals for hot water utilization would be extremely useful in Wyoming.

Shallow to Moderate Depth Hydrothermal Convective Systems

The third type of geothermal system in Wyoming is the shallow to moderate depth hydrothermal convective system. Low temperature resources (less than 90°C (194°F)) are usually associated with this type of system. Also, most of the hot springs located across Wyoming (Figure 2) are the surface manifestations of hydrothermal convective systems. With this type of geothermal system, water circulates in porous rock units to moderate depths (1500 to 2000 meters (5000 to 6500 feet)) where it is heated by the Earth's normal increase in temperature with depth. The warmed water then circulates upwards near the surface of the Earth by either an upwarp of the water-bearing rock units or a porous fault system. In the area of the upwarp warm waters can be found at relatively shallow depths. An example of this type of system is shown in Figure 3 which is a representation of a portion of the Thermopolis hydrothermal system. Figure 3 illustrates how water in the Madison Limestone can be heatd to 72°C (161°F) at a depth of 1900 meters (6200 feet) and then brought to within 760 meters (2500 feet)

of the surface. This type of geothermal system is relatively easily explored and the resources found can be used for direct heating purposes. Discussions of identified low-temperature resource areas of this type of geothermal system are contained in the next section on site specific areas.

SITE SPECIFIC AREAS WITH POTENTIAL LOW TEMPERATURE RESOURCES

The Thermopolis Areas

Temperatures, gradients and regional geology have been compiled for a 1800-1900 mi^2 area that is roughly centered on the town of Thermopolis (Figure 2). The results demonstrate that the thermal anomaly occurs all along the central part of the Thermopolis anticline, occupying a 20 mile long by 3 mile wide area that strikes west-northwest between the southwestern part of T. 43 N., R. 93 W. and the southeastern part of T. 44 N., R. 96 W. Within this zone, calculated gradients are in the range 43-300°F/1000 ft (78-547°C/km) and tabulated bottom hole temperatures range from 90°F (32°C) to 160°F (70°C) at depths less than 2000 ft ($\sim$.6 km). Inasmuch as downward continuation of the lower gradients predicts 60 + °C temperatures at depths between 3500 and 4000 ft (1.1-1.2 km), we consider all of the region to be a "viable" low temperature, hydrothermal resource area.

The Red Springs Anticline area in T. 43 N., R. 93 W. may be a "marginal" resource area. Here the calculated gradients are in the range 24-59°F/1000 ft (43-107°C/km). Consequently, 45°C waters might be encountered at 3900-4500 ft depth (1.2-1.3 km).

A tightly folded syncline is located immediately south of the Thermopolis anticline. We believe that waters from the Owl Creek Mountains are heated at the bottom of this syncline. Subsequent upward movement of these waters along the northern flanks of the syncline could explain the high gradients in the anticline. The thermal waters are most likely to be in the Tensleep and/or Madison Formations--two formations with porosities and permeabilities sufficient to yield the flow rates ($\sim$2800 gpm; Breckenridge and Hinckley, 1978) of the spring system in Hot Springs State Park. Within the central part of the anticline, the "tops" of the Tensleep and Madison range from 200-2800 ft (.06-.85 km) and 800-3450 ft (.24-1.08 km), respectively. It is possible, therefore, that these aquifers could be reached with economical drilling in some parts of the structure (see Figure 3).

Referring to "practical" aspects of resource development, one question that must be answered is whether drilling and large scale development would change temperatures and flow rates of the hot springs within Hot Springs State Park. A project is presently underway to gather hydrologic data for the Thermopolis area in an effort to answer this question.

The Cody-Horse Center Anticline System

This potential resource area is bounded by the DeMaris hot springs (27-39°C (30-96°F) 1700 gpm) just west of Cody and the Horse Center anticline about 7 miles to the south (Figure 2). The first evidence for a low-temperature resource was provided by the 29-205°C/km (27-112°F/1000 ft) gradients calculated using bottom hole temperatures in eleven dry oil wells in the anticline. Down hole measurements by Wyoming personnel agree with the oil well data. For example, least-squares gradients and maximum temperatures based on measurements in five shallow oil wells are in the ranges 96-190°C/km (52-104°F/1000 ft) and 38.4-47.5°C (101-117°F), respectively, at subsurface depths in the range 185-500m (607-1640 ft).

Data from six shallow temperature gradient wells drilled by the Department of Geology in early 1980 suggest that the area of greatest potential use is in T. 52 N., R. 102W., S ½ of section 11. In this area warm waters (34°C (93°F)) can be reached at shallow depths (51 to 300 meters (168 to 1000 feet)). The maximum temperature of this system may approach 55 to 65°C (131 to 149°F) at depths of 260 to 500 meters (853 to 1640 feet). Warm waters will be found at the shallower depths in the more western portions of this potential use area (see Heasler, 1980).

The main aquifers for the Cody-Horse Center hydrothermal system are the Tensleep Sandstone, Madison Limestone, and Bighorn Dolomite. These formations are reported to have good porosities and permeabilities with flows in the Madison Limestone and the Bighorn Dolomite sometimes exceeding 1,000 gallons per minute (Lowry, 1976). However, the water flow of wells drilled into these aquifers may vary greatly between wells due to secondary fracture permeability, secondary silica cementation of the Tensleep Sandstone, and the cavernous nature of the Madison Limestone and Bighorn Dolomite.

The Casper-Midwest-Douglas Area

Because of much local interest in utilization of hydrothermal resources in projected housing development, considerable effort has been spent researching these areas. Present data consist of more than 2,000 bottom hole temperature points, from which combined temperature gradient and geologic maps are being prepared.

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Most of our data are for areas near Midwest. These results clearly show that the Salt Creek Oil Field is a conspicuous thermal anomaly. Within this 10-12 mi^2 field, bottom hole temperatures between 1000 and 4500 ft (.3-1.4 km) are in the range of 120-170°F (49-77°C), and maximum calculated gradients are between 40 and 100°F/1000 ft (72-182°C/km). Additionally, water supply wells that penetrate the Madison Formation produce 184°F (84°C) waters that flow to the surface at a total rate of over ten million gallons per day (Collentine, et al., 1981). There can be little doubt, therefore, that Salt Creek Field could be used to produce hydrothermal fluids for direct heat applications in the vicinity of Midwest. The major impedences to resource development could be the relative values of hydrocarbon and geothermal resources, the high concentrations of solids in the non-potable waters, and the question of whether AMOCO Production Co., Wyoming, or the federal government owns the geothermal resource.

Scant data exist for the Casper region because fewer oil tests have been drilled in the area. The available data do suggest, however, that most of the region within a 10-15 mile radius of the city is not thermally anomalous. Calculated gradients are generally in the range 14-16°F/1000 ft (25-29°C/km) and temperatures are in the range 100-135°F (38 to 57°C) at depths of 3,500-4,500 feet (1,070-1,370 meters).

Two reliable heat flow values are now available for the Douglas area (Figure 2). The values are in the range 2.0-2.2 HFU. These drill holes are in an area where the underlying Madison Formation is dipping up to shallower depths from the north, northeast. Perhaps upward circulating waters in the Madison explain the observed above-normal flux. More reliable definition of the suggested resource area will require additional research with shallow drill holes.

Gradients in 5 shallow holes near Torrington are in the range 23-29°C/km (13-16°F/1000 ft). In the Wright area to the north, measurements in 10 holes suggest that the undisturbed regional gradient is between 19 and 29°C/km (10-16°F/1000 ft). The meaning of these data is obscure, but one interpretation is that the eastern part of the Powder River Basin is characterized by a complex pattern of normal to high heat flow and perhaps shallow low-temperature hydrothermal reservoirs in isolated areas. We cannot be more specific without more geothermal data for the Basin.

Research in the Casper-Midwest-Douglas area is continuing in an effort to locate potential resource areas and to better define heat sources and hydrothermal water movement.

The Gas Hills Area

Research before 1979 revealed the presence of high gradients (42-100°C/km) at 8 isolated drill holes on the Beaver Rim, in the Gas Hills east of Lander. Recently compiled data consist of 20 bottom hole temperatures and temperature measurements in 31 holes that were drilled during uranium exploration. Maps of heat flow, gradient and regional geologic data are in various stages of compilation.

The present data are consistent with a complex pattern of gradient and flux in the Hills. Briefly, observed gradients range from 20°C/km to 100°C/km (11-55°F/1000 ft) and estimated heat flows are in the range 1.2-2.3 HFU. From combined geothermal and geologic data, one hypothesis is that faults control the gradient and heat flow patterns. Thus, any development of geothermal resources is likely to require careful mapping of the local geologic structure to delineate fault zones that could yield water with potential for direct-heat applications. We hope to conduct more studies in the area because the great interest in subsurface uranium could lead to local settlements and because one deep oil test in the Hills is reported to have encountered high temperature waters in the Madison (J. D. Love, personal communication, 1980).

The Saratoga Valley Thermal System

Our DOE cooperative agreement has allowed us to establish a gradient and heat flow profile that extends from the eastern edge of the Washakie Basin to the Laramie Mountains (Figure 1). Gradients and preliminary heat flow values along this profile are in the ranges 7-30°C/km (4-16°F/1000 ft) and .9-1.6 HFU, respectively. Two holes on the profile are near the hot springs in the town of Saratoga (Figure 2). The gradient in the hole about 1 mile west of the springs is 20°C/km (11°F/1000 ft), and that in the hole about 1 mile to the east is 30°C/km (16°F/1000 ft). Both gradients may be considered "normal", and so these observations suggest that the Saratoga hot springs ($\sim$50°C (122°F); Breckenridge and Hinckley, 1978) are not surface manifestations of a subsurface hydrothermal system with large dimensions. The narrow width of the system, in turn, suggests that the springs could be flowing from faults in this part of the Saratoga Valley. This view is supported by geologic evidence for a fault zone near the spring system (Montagne, 1955). Like the Gas Hills, development of geothermal resources in the Saratoga area may require additional research on the correlations between faulting, subsurface temperatures and heat flow in the region.

We may speculate that moderate or higher temperature resource areas could be present at shallow depths in the region between the Saratoga Valley and the southern Rocky Mountains in northern Colorado. From our new data, the heat flow is normal or low (.9-1.6 HFU) in the Saratoga Valley-Sierra Madre Mountains-Medicine Bow Mountains region in Wyoming, whereas the flux is high ($\geq$2.4 HFU) at Hahns Peak and Northgate, Colorado, about 50-60 km (31-38 mi) to the south. Interpreted in terms of steady or transient heat sources, the width and magnitude of the transition suggest that the excess flux in northern Colorado is partly due to high temperature heat sources at shallow depths in the crust and/or upper mantle. This view, in turn, is consistent with geothermal reservoirs in the transition zone and the high heat flow area immediately to the south.

EXISTING AND PROPOSED GEOTHERMAL USES

Existing uses of geothermal resources in Wyoming are low-temperature direct-use projects. The greatest single use is recreational as in swimming pools and spas such as The State Bath House in Thermopolis. One green-house and three private homes are geothermally heated. The Wyoming Highway Department has constructed two heat pipe bridges (one near Laramie and one near Wheatland) that use geothermal heat to help keep the bridges ice free. Also, the town of Frannie in the northern Bighorn Basin utilizes 32°C (90°F) well water for their domestic water supply and minor heating purposes.

Proposed geothermal projects within the State also deal with the direct use of low-temperature resources. The U.S. Department of Housing and Urban Development has recently funded a $50,000.00 geothermal district heating feasibility study for the town of Thermopolis. Also in the Thermopolis area two geothermal green houses (34 feet by 90 feet each) are being built. In the Cody area interest has been expressed in geothermally heating two subdivisions containing 200 homes. One proposed small ethanol plant in the Bighorn Basin is considering using oil field treater water as a heat source. Other known potential uses of geothermal resources in the State include a greenhouse and aquaculture facility near the town of Midwest, possible district heating of Midwest, and use by an ethanol plant or cheese plant near the town of Thayne.

CONCLUSION

Present data indicate that the geothermal resource in Wyoming is primarily a low to moderate temperature resource within large areas of sedimentary basins. In most cases, although the resource extends over a large area, it is at too great a depth to be drilled economically solely for geothermal utilization. However, many unsuccessful oil and gas wells do encounter this geothermal resource. Such wells could successfully be used in the production of low to moderate temperature geothermal fluids for the beneficial direct use of the resource.

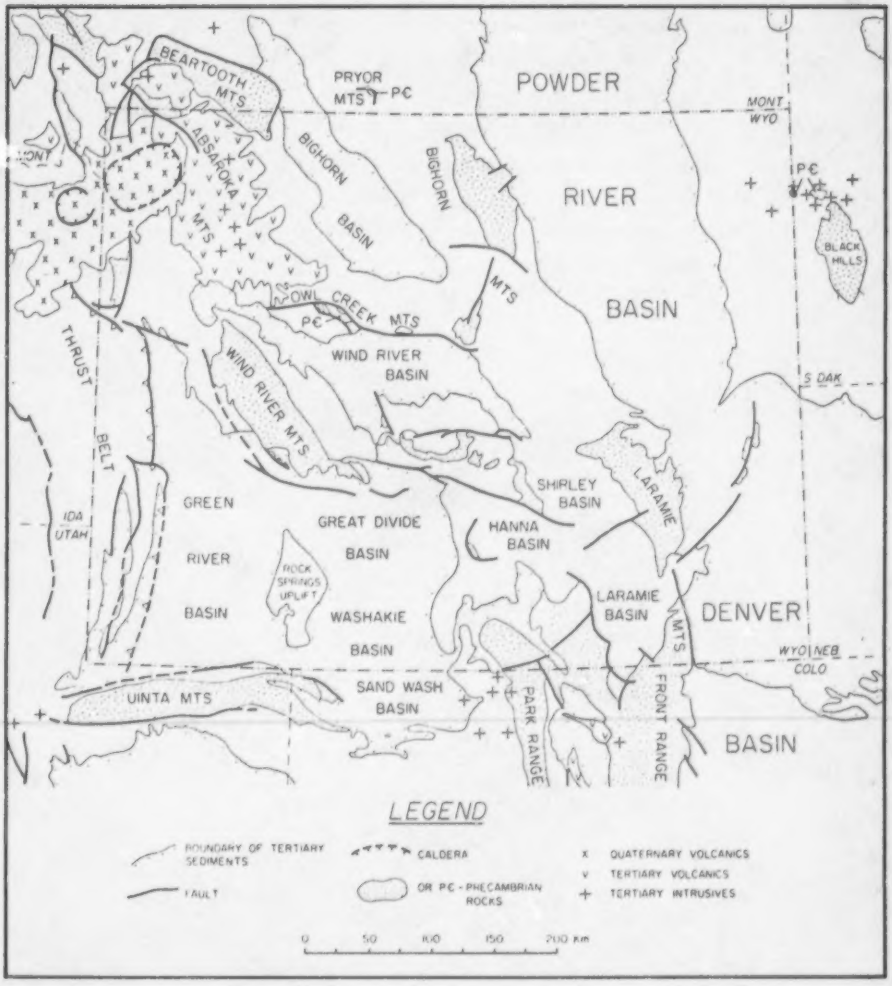

Figure 1. Generalized geology of Wyoming showing major structural features and locations of basins.

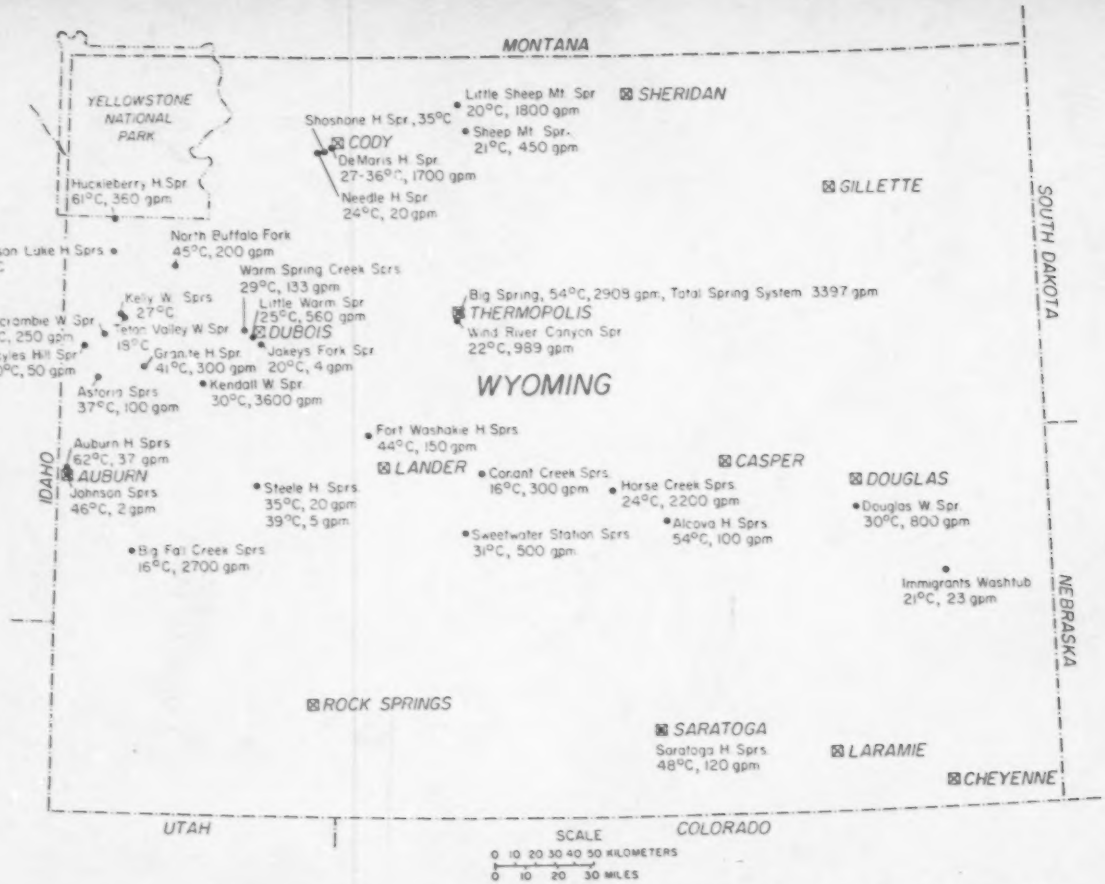

Figure 2. Thermal springs of Wyoming exclusive of Yellowstone National Park. Data primarily from Breckenridge and Hinckley, 1978.

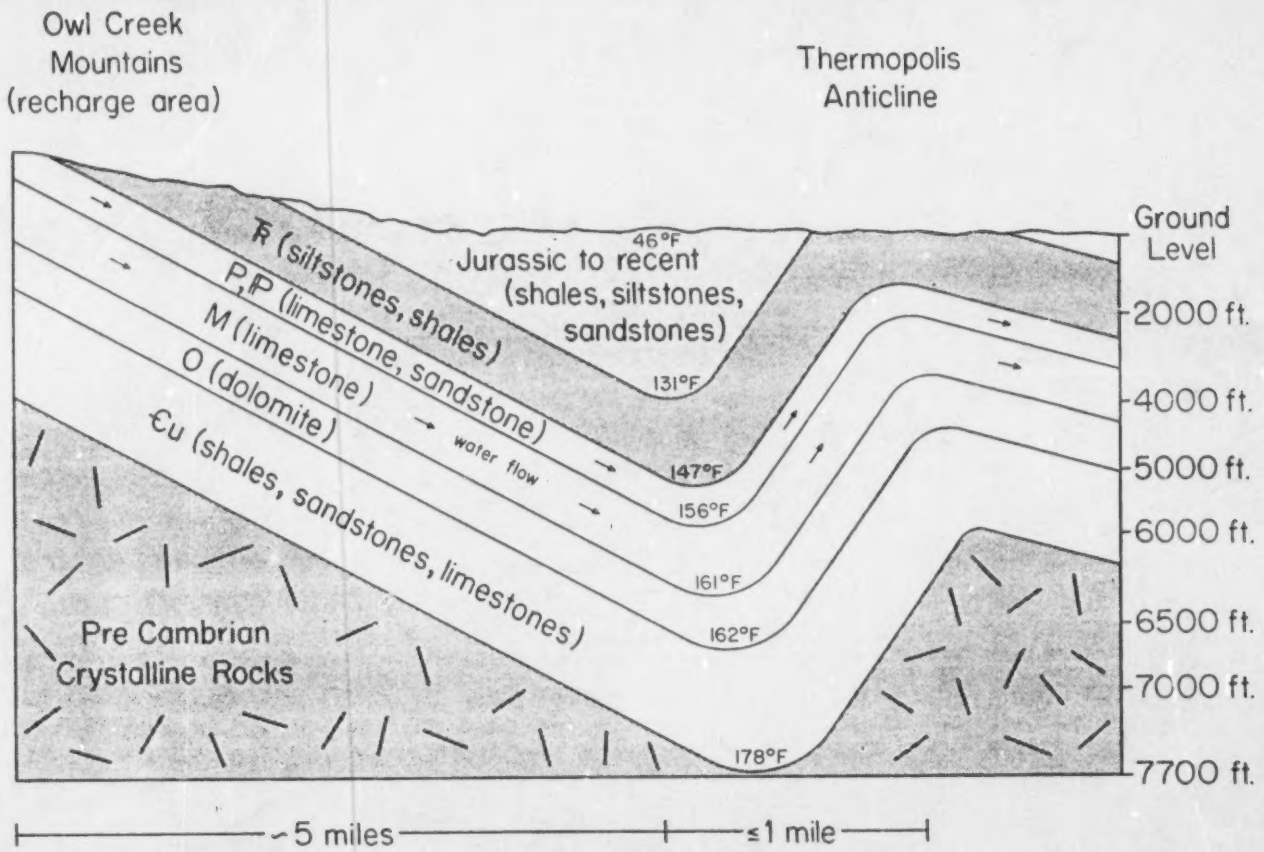

Figure 3. Cross-section of the Thermopolis low-temperature hydrothermal system illustrating how warm waters in the Madison Limestone are brought close to the surface.

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EVALUATION OF THERMALLY ACTIVE AREAS IN SOUTHWESTERN YELLOWSTONE NATIONAL PARK

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INTRODUCTION

Production from known geothermal areas adjacent to southwestern Yellowstone National Park could affect thermal activity within the park (U.S. Dept. of Agriculture, 1979). To assess the possibility for impact, it is essential to inventory the thermally active areas in the southwestern corner of Yellowstone Park and to determine the physical relationships between geothermal areas inside the Park and those outside the Park. This assessment should include both an examination of the chemistry of effluent thermal waters and the geologic system which controls the movement of the thermal waters.

Part of the needed information can be obtained by remote sensing. Thermal infrared imagery provides a way to efficiently inventory thermal anomalous areas, and structural interpretations of radar and LANDSAT imagery provide information about the regional structure and fracture systems which often serve as conduits for thermal waters. This report summarizes an effort to apply remote sensing to these problems. No attempt has yet been made to evaluate comprehensively the chemistry of natural spring waters in this region, but we anticipate that the geologic work may shortly be supplemented with geochemical data, so that a more complete picture can be drawn of the geothermal system in the region of southwestern Yellowstone Park.

OBJECTIVES

The chief objective of the research discussed in this report was to gather information about geothermally active areas in and adjacent to southwestern Yellowstone National Park. The proposed research program included geologic interpretation of remote sensor data, field checks, and chemical analysis of water samples. But, the proposal was only partially funded, so it was necessary to restrict the project goals to a geologic evaluation of the region from available remote sensor data. The available data included high- and low- altitude aerial photos, LANDSAT imagery, thermal scanner data, and radar imagery. An effort was also made to use the new thermal data from the HCMM satellite for regional analysis of thermal patterns.

The thermal infrared imagery and aerial photography was used to complete an inventory of thermal activity in the regions, and the other data were employed in interpreting the structural trends and relationships between thermal areas.

STUDY AREA

The study area is the southwest corner of Yellowstone National Park (Fig. 1). The area is bounded on the north by latitude 44°30' west which passes halfway between the Upper Geyser Basin and Midway Geyser Basin, and on the east by longitude 110°38' north which bisects Lewis Lake. The study area also includes a swath 3.2 km (2 mi.) wide outside the park, which follows the park boundaries on the south and west sides. Few data sets covered

the entire study area, and most analyses were confined to the section within the park and southwest of the Continental Divide.

The area encompases 1742 km^2 (672 mi^2) and is included in the Buffalo Lake, Grassy Lake Reservoir, Huckleberry Mtn., Old Faithful, Warm River Butte and West Thumb 15-minute topographic quadrangles (U.S.G.S., 1956, 1957). Numerous high plateaus, canyons, and lowlands make up this portion of the Park. Elevations range from nearly 2950 m (9,000 ft.) on the Pitchstone Plateau to 2030 m (6,186 ft.) where the Falls River leaves the Park. The area comprises dense forests, lush meadows, marshes, lakes, and large open areas devoid of vegetation. The Falls River, Bechler River, Robinson Creek and their tributaries drain the region. The area contains numerous waterfalls, giving rise to the name "Cascade Corner" for this portion of the Park.

The northern portion of the study area is made up of numerous, thickly-layered Quaternary rhyolite flows. The southern part contains primarily a mixture of ash-flow tuffs, basalt flows, detrital deposits, sedimentary rocks and Absaroka Supergroup volcanics and associated intrusive rocks (U.S.G.S., 1972b). These have been re-worked into till, lacustrine, and alluvial deposits as a result of the Bull Lake and Pinedale glaciations (U.S.G.S., 1972a). Quaternary normal faulting has occurred at several locations throughout the southern part of the study area and in the northern part near Trischman Knob (U.S.G.S., 1972a, 1972b).

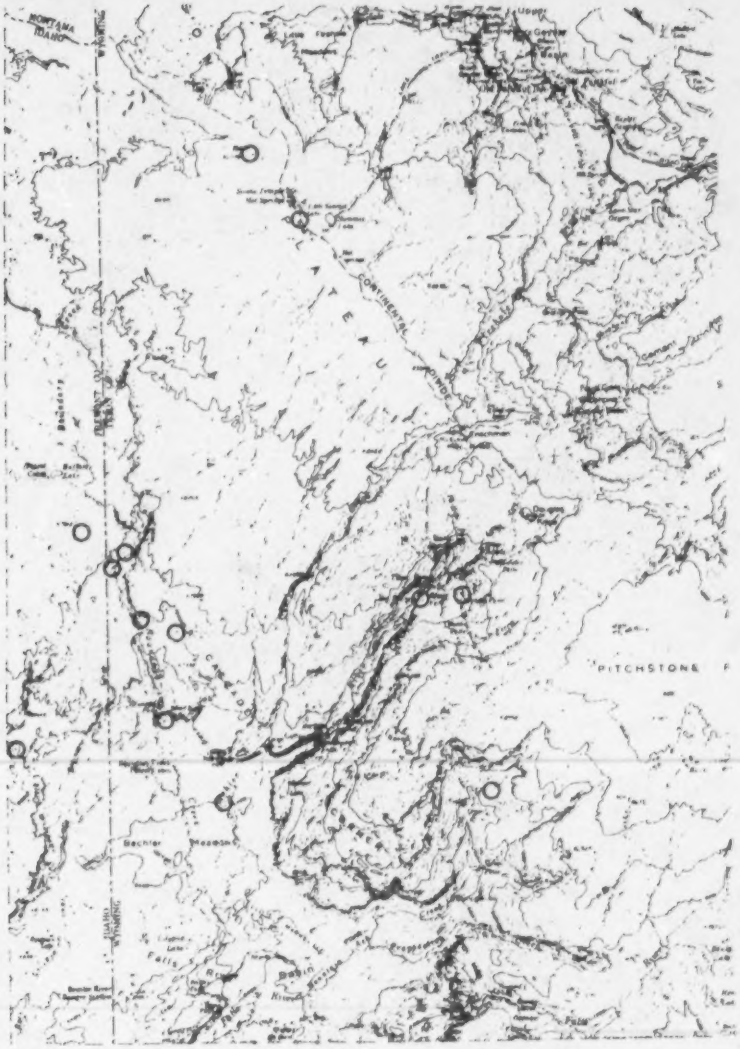
Thirteen areas of thermal activity have previously been identified in the area (Hutchinson, 1977, and Hutchinson, personal communication). These known thermal areas are shown in Figure 2. Detailed descriptions of these thermal areas, including temperature and discharge measurements are presented by Hutchinson (1977).

PREVIOUS WORK

General descriptions of the geological history, landforms, and petrology of the region can be found in Keefer (1972), Breckenridge and Hinckley (1978), and Parsons (1964). Discussions of the hydrology of Yellowstone National Park and descriptions of geysers, hot springs, and other thermally active features can be found in the landmark publication by Allen and Day (1935) and in Breckenridge and Hinckley (1978). Marler and White (1975) describe the evolution of Seismic Geyser in the Upper Geyser Basin after the 1959 West Yellowstone earthquake. They propose a model for the origin of geysers and hot springs whereby old fractures and permeable channels become sealed by precipitation of hydrothermal minerals and new channels are provided by periodic seismic activity. Truesdell and Fournier (1978) describe a deep aquifer model based on geochemistry, temperature, and pressure data and discuss its effects on shallow hydrothermal features. They propose a single, large, slowly-cooling magma body (at a depth of about 6 km), as the heat source for the entire Yellowstone thermal system. White et al (1975) provide a detailed account of pressure, temperature, and basic chemical determinations for thirteen drill holes in the principal thermal areas of Yellowstone.

Figure 1. LANDSAT MSS image (1771-17311, 2 September, 1974) of the Yellowstone National Park region showing the location of study area. The LANDSAT scene is reproduced from the computer-enhanced color composite constructed by EROS Data Center, Sioux Falls, South Dakota.

KNOWN THERMAL AREAS IN SOUTHWESTERN YELLOWSTONE NATIONAL PARK



O THERMALLY ACTIVE AREA

BASE MAP: YELLOWSTONE NATIONAL PARK
WYO.-MONT.-IDAHO 1961
U.S.G.S. 1:250,000 - SCALE TOPOGRAPHIC MAP
CONTOUR INTERVAL: 80 FEET

ADAPTED FROM HUTCHINSON, 1977

Figure 2.

They discuss drilling problems and the effects of short-circuiting natural aquifers by drilling. Volcanic history of the Yellowstone rhyolite plateau and Snake River Plain are described by Christiansen and Blank (1969). They note that these regions lie along a continuous trend and have evolved as a single volcano-tectonic system. They interpret this system to be a tensional rift that has opened progressively northeastward. The Island Park and Yellowstone calderas are recent events in this active system. Bonnichsen, Traverse, and Citron (1975) describe the rhyolitic volcanism and structural evolution of the Snake River Plain region. They propose that the western Snake River Plain is a graben, probably related to the northwest-southeast-trending fault system in central and eastern Oregon, however, they believe that the eastern Snake River Plain reveals the regional downdropping that followed the time-transgressive linear volcanism which progressed from southwestern Idaho or northwestern Nevada to Yellowstone Park. Detailed descriptions of the geology, petrogenesis, and hydrology of the Island Park caldera are given in Hamilton (1965) and U.S. Dept. of Agriculture (1979). Long, O'Donnel, and Smith (1975) made several geophysical studies in the Island Park caldera area. They constructed maps from aeromagnetic, gravity audio-magnetotelluric, and telluric current sounding surveys. They show that a regional magnetic high corresponds to regions of low resistivity outside the caldera, to the northwest. Within the caldera, the high apparent resistivity, gravity high, and aeromagnetic low all correlate with a boundary of an older and younger caldera. They state that the gravity field over the Island Park area is transitional between the gravity high in the Snake River Plain and the gravity low in the Yellowstone Park area. Rambo and Blank (1968) performed a regional gravity survey from the Madison Plateau in Yellowstone to the Snake River Plain. They observe that the Island Park complex is bounded by northeast-trending gravity lineaments that appear to represent the structural margins of the Snake River Plain.

In recent years, the science of remote sensing has greatly improved our capability to extract quantitative information from image data (Barrett and Curtis, 1976; Lintz and Simonett, 1976; Reeves, 1975). Advances in thermal infrared technology have provided valuable new tools for analysis, inventory, and monitoring of thermally active areas (Hodder, 1970, Kahle, et al., 1975; Lyon, 1976; Seigal et al., 1975; Watson, 1975). Recent development of powerful techniques for image enhancement and interpretation have allowed extremely subtle image contrasts to be detected and mapped (Levinson, Marrs and Grantham, 1976; Goetz and others, 1975). These techniques may be applied to thermal infrared photographic, and side-looking radar (SLR) data to aid in geothermal resource planning. Interpretations of thermal and multispectral imagery may be combined with on-site investigations of geochemistry, geologic structure and hydrology to produce a more complete thermal inventory of large areas and help define physical relationships between thermal areas. McLerran and Morgan (1965) and Miller (1966) studied early thermal infrared imagery obtained over Yellowstone National Park. They demonstrate that thermal infrared sensing is useful for mapping hydrothermal features. This technology (which was relatively new at the time of investigation) was especially useful for identifying areas of anomalously hot earth or shallow subsurface thermal anomalies which were not evident from surface hydrothermal features. Keefer (1968) looked at more recent thermal infrared imagery, as well as side-looking

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radar imagery, obtained over south-central Yellowstone, to determine if either type of imagery could be used to delineate structural features or differentiate among rock types. His results were largely unsuccessful. The sedimentary rocks in the area had no detectable tonal characteristics on either type of imagery, except for Quaternary surficial deposits which were detected on the infrared imagery. Faults could be detected only where expressed by topography. Doherty and Nash (1977) used LANDSAT imagery. Together with SLR and high-altitude photography to identify mapped geological features associated with the Yellowstone and Island Park calderas. The critical features they recognized in the imagery were short linears (<3 km), long linear (<3 km), very light tonal anomalies which indicate hydrothermally altered terrain, radial drainage down the flanks of caldera shields, and small- and large-scale rectilinear drainage patterns which indicate deep faults or fracture zones. Using these criteria, two possible calderas were discovered.

THERMAL ACTIVITY

Thermal features in the 13 known areas include hot and warm springs, thermal pools, turbid springs, seeps, hot steaming ground, which is barren of vegetation, fumaroles, and mudpots. Only one active geyser has been identified in the area (Hutchinson, 1977). Siliceous sinter and travertine deposits are common in these areas. Occasionally, terraces are formed.

Most of the major thermal areas in Yellowstone National Park are related to the ring fracture zones of the Yellowstone caldera (Keefer, 1971). However, most thermal areas in the study area are located southwest of the proposed outline of the caldera (Keefer, 1971). Two of the known thermal areas in the study area (#1 and #2, Hutchinson, 1977) are located on the margin of the caldera as described Keefer (1971). The Upper Geyser Basin and Lone Star thermal area are located on ring fracture systems within this caldera. However, the other known thermal areas in the study area are outside the outline of the Yellowstone caldera. The structural control in these areas is more difficult to determine. They are probably controlled by fracture zones. Faulting and joint systems could provide convenient conduits where water could circulate to great depths, become heated, and rise to the surface as hot water or steam. Permeable rocks at depth could provide channelways for hot water or steam and aid in the overall circulation.

PROCEDURE

Pertinent literature, maps, and publications were first gathered and reviewed to establish research goals and procedures. The park geologist, park biologists, and the district ranger were contacted to determine field conditions and the nature of known thermal activity in the area. Because a field program was not funded for this stage of the study, the use of remotely sensed data was imperative. A thorough search was made for all available aerial photography, airborne scanner data, and satellite imagery covering

the study area. Some of the data used (Table 1) were enhanced using photographic techniques and using the video image analysis system at the University of Wyoming Remote Sensing Laboratory (Levinson, Marrs, and Grantham, 1976). Textural, spatial, and spectral features on the imagery which could indicate thermal activity or geological structures were identified and mapped. The features indicative of geological structures were treated statistically in order to delineate trends which could be evaluated within the framework of the regional geology.

IMAGE ANALYSIS

Several types of imagery have been used to evaluate the study area for thermal potential. These included: airborne thermography, color and color infrared aerial photography, black-and-white orthophotography, satellite scanner imagery and SLR imagery. Table 1 lists all remote sensor data used in this investigation.

Thermography

We obtained a thermographic mosaic of Yellowstone National Park (Table 1, University of Michigan Institute of Science and Technology, 1969). These data were acquired near midnight on April 9-10, 1969, from an elevation above mean terrain of 5,487.8 m (18,000 ft.). Snow-cover in the park was near its maximum annual extent at this time. Sharp contrasts between snow-covered and non-snow-covered areas provide a natural threshold for thermal activity. Thermally active areas appear light-toned, indicating a high rate of thermal emission. Large thermal features such as the geyser basins and large warm rivers were easily recognized. Individual geysers or hot springs could only be detected if they had a sufficiently large surface expression. The thirteen known sites of thermal activity in the study area could be identified only by knowing previously where they were. Many other light-toned areas were evident. These could be caused by dust, system noise, or reproduction defects. These false tonal anomalies can easily be confused with real thermal anomalies on the mosaic.

The original imagery from which the mosaic was constructed (Table 1, H. R. B. Singer, 1966) was also acquired (courtesy of U.S.G.S.). These data (Fig. 3) were enlarged and contrast-stretched on the video image analysis system at the University of Wyoming Remote Sensing Laboratory (Levinson, Marrs and Grantham, 1976). Unfortunately, the interpretations were still largely inadequate. The same large-scale thermal features could be recognized, and more small features, within large thermally active areas, could be identified. The thirteen known thermal areas could be recognized; and in areas 1, 2, 10, and 13 (Hutchinson, 1977), several individual thermal features could be recognized. Several other light-toned anomalies, which appear similar to these known thermal features, were observed. However, due to the presence of dust, and image noise, these anomalous areas could not be positively identified as thermal in origin. The major problem with the quality of this thermal imagery is ramp distortion (darkening of the film toward the edges) which makes tonal interpretation and image density contouring across the image impossible.

Table 1 Remote Sensor Data Available for Thermal Inventory and Structural Evaluations in Southwestern Yellowstone National Park.

Date	Mission (Title)	Type of Data
1965	Westinghouse	Side looking Radar (SLR) K-band, plane- and cross- polarized (HH and HV)
1966	H.R.B. Singer	3.5 - 5.5 μm infrared thermography Reconofax IV.
1966	NASA	8 - 14 μm thermal scanner
1969	NASA, MX 101	Color and color infrared aerial photography 1:120,000-scale
1969	Univ. of Mich. Inst. of Science and Technology	Thermographic Mosaic of Y.N.P. 3.5 - 5.5 μm infrared thermography (H.R.B. Singer).
1969-1971	National Park Service ETZ Series	Color aerial photography 1:16,400-scale
1974	U.S.G.S. Orthophotography Buffalo Lake NE, ID-WY-MT Buffalo Lake SE, ID-WY Grassy Lake Reservoir NE, WY Grassy Lake Reservoir NW, WY Warm River Butte NE, ID-WY	Panchromatic aerial photography 1:24,000-scale
1974	LANDSAT MSS 1771-17311 2 September, 1974	Band color composite .4 - 1.1 μm 1:1,000,000-scale
1978	Heat Capacity Mapping Mission A-A0154-09160-3, 27, September 1978 A-A0153-08580-3 26, September 1978	Thermal satellite, 8 - 14 μm night and mid-afternoon
1978	LANDSAT RBV 30124-17294 7 July, 1978 30142-17300 25 July, 1978 30178-17302 30 Aug., 1978	Panchromatic .5 - .7 μm 1:500,000-scale

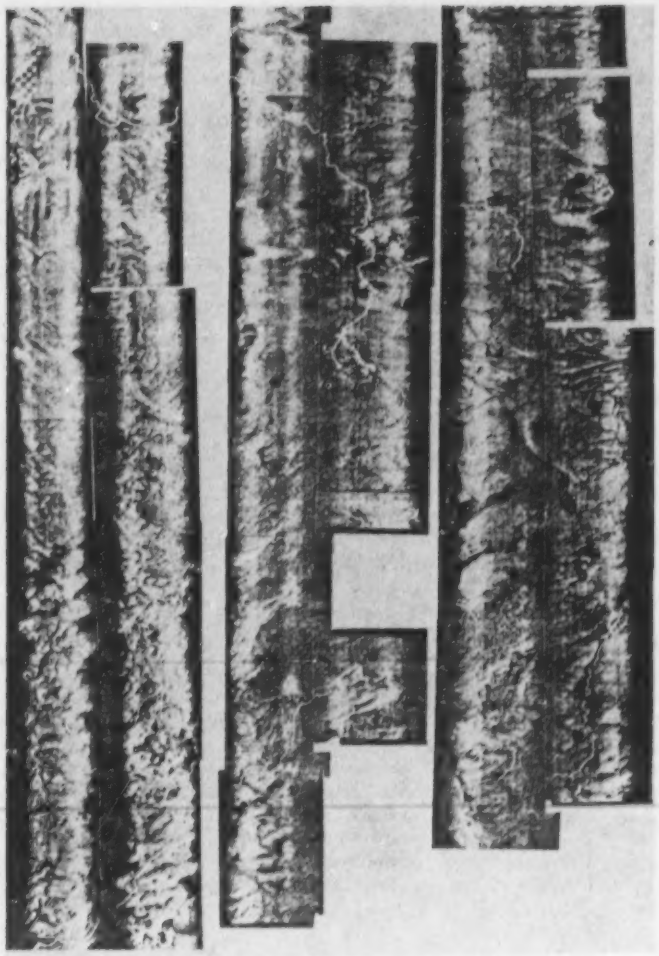


Figure 3. Thermal infrared image mosaic of a portion of the southwestern Yellowstone Park study area (April 9-10, 1969; night). Note the severe changes in greytone (ramping) across each image strip and the lack of overlap between some adjacent strips.

There are also many scratches and film processing stripes running lengthwise on the film. Enlargement of the thermography was necessary to see detail because of the small scale of the original imagery. But, enlarging the images emphasized scan-striping, dust marks, and processing noise such that it became a hindrance to image interpretation. Blackbody and graybody calibration stripes were not provided on the thermography so that quantitative thermal measurements could not be made. Some portions of the study area were not covered by the thermal data (Fig. 3).

Other airborne thermal scanner data (Table 1, NASA, 1961-1969) obtained over various portions of Yellowstone National Park were also acquired (courtesy of U.S.G.S.) Most of these data were unlabeled and information such as exact spectral bands, flight times, flight elevations, etc., was not available. Much of these image data were oblique rather than vertical in view. Still, once the flight lines were located, these data provided very useful supplements to existing thermal coverage of the study area.

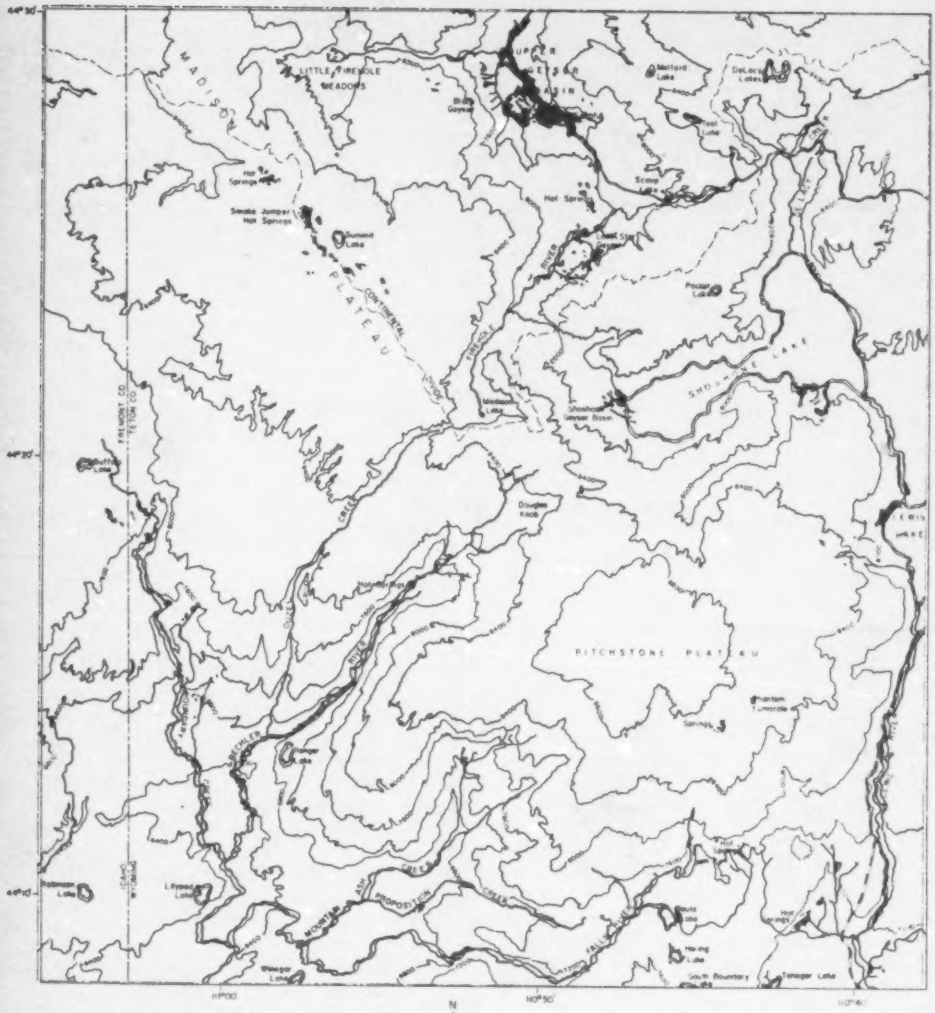
A map showing the compilation of all thermal features observed on all thermography is given in Figure 4. This map shows all thermal features encountered in our inventory of the southwest corner of Yellowstone. Type of thermal feature (hot spring, geyser, fumerole, hot earth) could not be determined. The thirteen known thermal areas (Fig. 1) were mapped in moderate detail. Many other thermal areas and warm rivers are also shown in Figure 4. All of these areas warrant further investigations into type of feature, temperatures, discharge, etc., and detailed mapping of each area.

Aerial Photography

Hydrothermal deposits associated with thermal areas (geyserite, travertine, siliceous sinter) have a high reflectance in the visible and near-infrared wavelengths which makes them appear as extremely bright areas on aerial photographs. In the study area, these deposits appear even lighter than the hydrothermally altered rocks reported by Doherty and Nash (1977). A preliminary photo interpretation of the study area was made from high-altitude, 1:120,000-scale photography flown by NASA in August 1969 (Mission 101, Lines 1 and 2). This photography was available in both color and color infrared films. The quality of this coverage was poor; both film strips were severely underexposed and was not suitable for spectral interpretations. Also, the scale of this photography was too small to locate many known thermal features.

The National Park Service has made high-quality, low-altitude, 1:16,400-scale color photography available to us, (Table 1, ETZ series, 1969-
This photography covers the entire study area in stereo. Thermal areas have been successfully identified in other areas of the park from this coverage (Levinson and Marrs, 1975, Plate 1). Areas of high albedo were identified and mapped (Fig. 5). This map of thermal areas is incomplete and not as accurate as the map of thermal areas interpreted from thermography (Fig. 4)

THERMAL AREAS OF SOUTHWESTERN YELLOWSTONE NATIONAL PARK
COMPILED FROM ALL AVAILABLE THERMAL INFRARED DATA



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NOTE BLACK AREAS AND LINES INDICATE WARM REGIONS

because the coverage was flown by daylight. Many bright spots may be ponds or small pools reflecting sunlight back to the camera and thus, are not "true" thermal features. Many "true" thermal features do not have hydrothermal deposits associated with them. Others are located in such densely vegetated areas that it is impossible to see the deposits. The thermography was acquired at night and shows only "true" thermal areas (hot and warm areas at the surface) which will appear anomalous on the image data.

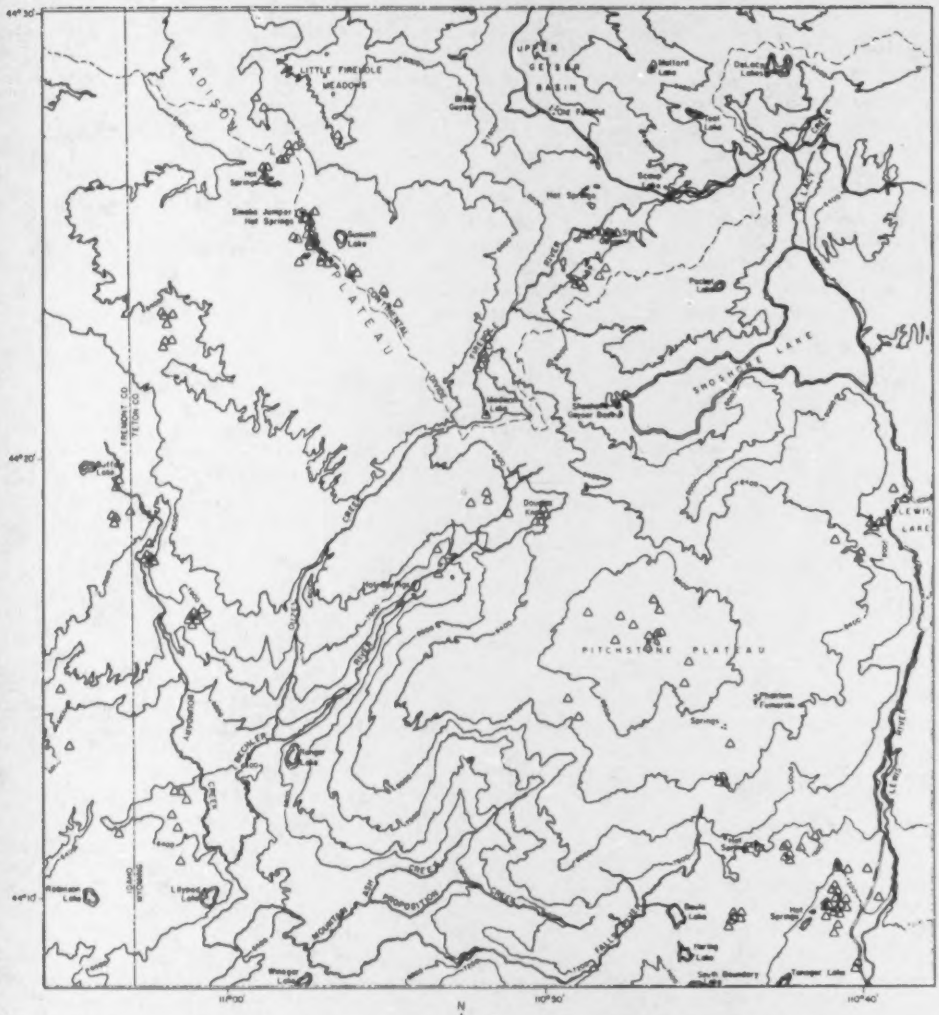
"Quad-centered" orthophotography presents full photographic information in a geometrically corrected form that is planimetrically accurate and centered on U.S.G.S. 7 1/2-minute series topographic maps (Reeves, 1975, pp. 628-629). Advance prints of six 1:24,000 scale orthophoto quads covering the southern and western portion of the study area was available from the U.S.G.S. (Table I, U.S.G.S. orthophotography). These were prepared from 1:80,000-scale black-and-white aerial photographs taken on September 2 and 18, 1974. The scale of this coverage was larger than the Mission 101 photography, and several of the known thermal areas were recognized. However, the orthophotography could not be used effectively to inventory thermal areas. The tonal reproduction on these advance prints (screened imagery on diazo paper) was poor. All light-tined areas appear similar; thermal areas did not look uniquely brighter. This may be in part, due to the quality of the imagery; but it is more likely that hydrothermal deposits have a unique spectral contrast that is seen only on color or color infrared films which have a greater dynamic range through the presentation of brightness, saturation and hue. Only when using the color information can hydrothermal deposits be distinguished from most other light-toned areas which appear similar on black and white photography.

Satellite Imagery

Three types of satellite imagery were available for this study (Table I). The LANDSAT multispectral scanner (MSS) data, which have been available for several years, provides a broad overview of Yellowstone Park (Fig. 1) with a resolution of 79 m (259 ft.) and spectral information in two visible and two near infrared (non-thermal bands). They are suitable for defining major geologic features (large faults, volcanic centers, folds, etc.) but lack the resolution necessary for more detailed interpretations.

Structural interpretation of imagery relies mainly on tonal and textural contrasts, so multispectral aspects of the LANDSAT MSS data were not of great advantage in this study. Consequently, we elected to use the new LANDSAT Return Beam Vidicon (RBV) imagery for structural interpretation (Fig. 6). These images still provide a regional perspective, but provide higher resolution with no spectral information. The LANDSAT RBV is a twin vidicon camera system which views two areas simultaneously. The optics of each camera covers a 100-km by 100-km area with each scene overlapping slightly with the scene covered by the adjacent camera and sequenced to obtain full coverage along each ground track. A set of four RBV subscenes cover the

THERMAL AREAS OF SOUTHWESTERN YELLOWSTONE NATIONAL PARK
INTERPRETED FROM LOW-ALTITUDE AERIAL PHOTOGRAPHY



FEATURES WERE INTERPRETED FROM LOW-ALTITUDE COLOR PHOTOGRAPHY OF YELLOWSTONE NATIONAL PARK (ETZ-SERIES). OUTLINED AREAS REPRESENT HIGH REFLECTANCE INTERPRETED AS HYDROTHERMAL DEPOSITS. TRIANGLES INDICATE OTHER AREAS OF HIGH REFLECTANCE WHICH MAY BE ASSOCIATED WITH THERMAL ACTIVITY.

LEVINSON AND LANDENBURGER, 1979

same region as a single scene of the LANDSAT multispectral scanner. Consecutive satellite coverage tracks are imaged on consecutive days; and, at the lattitude of Yellowstone Park, the consecutive tracks overlap by almost 40%; so a large part of the image area can be viewed in stereo. The chief advantage of the LANDSAT RBV system is the increased spatial resolution 38 m (125 ft.) which it offers. The system records almost twice the detail of the LANDSAT scanner system, (compare Figs. 1 and 6) and the manner of recording the information in four subscenes allows the detail to be preserved.

A linear features map (Fig. 7) was compiled from the interpretation of the LANDSAT RBV data in an effort to define the major fractures, faults and structural trends in the area. This method was successfully demonstrated by Bryant, Offield, and Schmitt (1973). The RBV lineaments were transferred to the U.S.G.S. 15-minute topographic maps for comparison with geology, topography, and thermal data. A rose diagram was constructed to define trends in the linear features.

We also attempted to use the thermal data from the new Heat Capacity Mapping Mission (HCMM) satellite to define broad thermal patterns (Table 1). This satellite provides images of very regional perspective (700 x 700 km (435 x 435 mi.)) for both daytime and nighttime overpasses (Goddard Space Flight Center, 1978). The nighttime thermal imagery is generally considered best for detection of thermal patterns related to rocks, soils, and vegetation because the differential heating of slopes by the sun and microclimate effects are less apparent at night. Even so, the scale and resolution of the HCMM data were such that they did not provide adequate detail for this study.

Side Looking Radar (SLR) Imagery

Side looking radar (SLA) imagery of the southwestern Yellowstone Park Area (Fig. 8) was made available through the courtesy of the U.S.G.S.

The long-wavelength energy imaged by the SLR system, the cloud-penetrating capability, and the unique viewing geometry of SLR yield imagery that is especially useful for geologic interpretations. Contrasts in scene brightness record differences in moisture, vegetation, slope, and surface roughness which may or may not be visible on thermal or photographic imagery. The low-angle illunination of SLR energy produces a "shadow effect" which enhances even the most subtle totographic features. This enhancement is particularly helpful in identifying faults, fractures, or other structural features that are topographically expressed. Because many of the structural features of southwestern Yellowstone Park are topographically expressed, a second map of linear features (Fig. 9) was compiled from the radar imagery. The radar interpretation identified some features not visible on the LANDSAT RBV data. However, other features expressed as tonal contrasts on the RBV imagery were not visible on the radar images. The two interpretations complement one another very nicely.

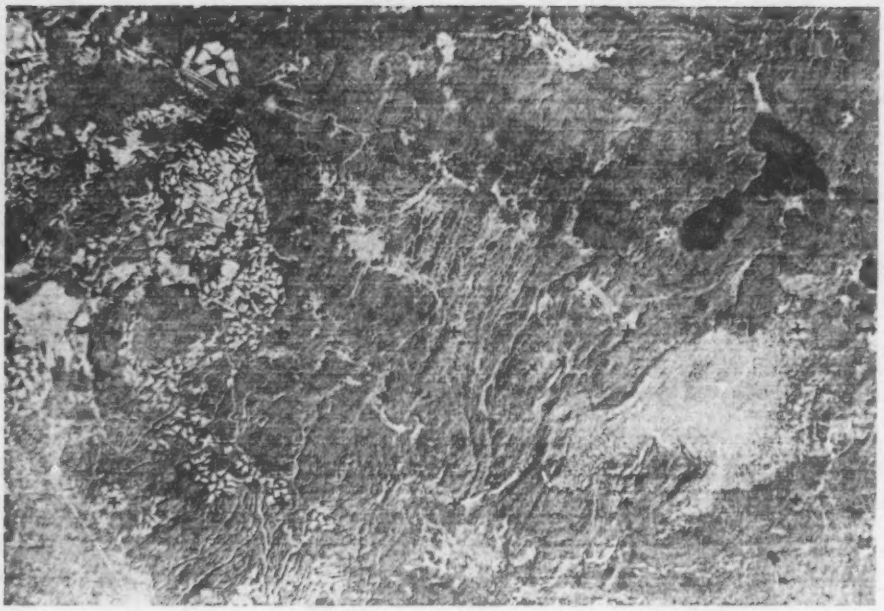
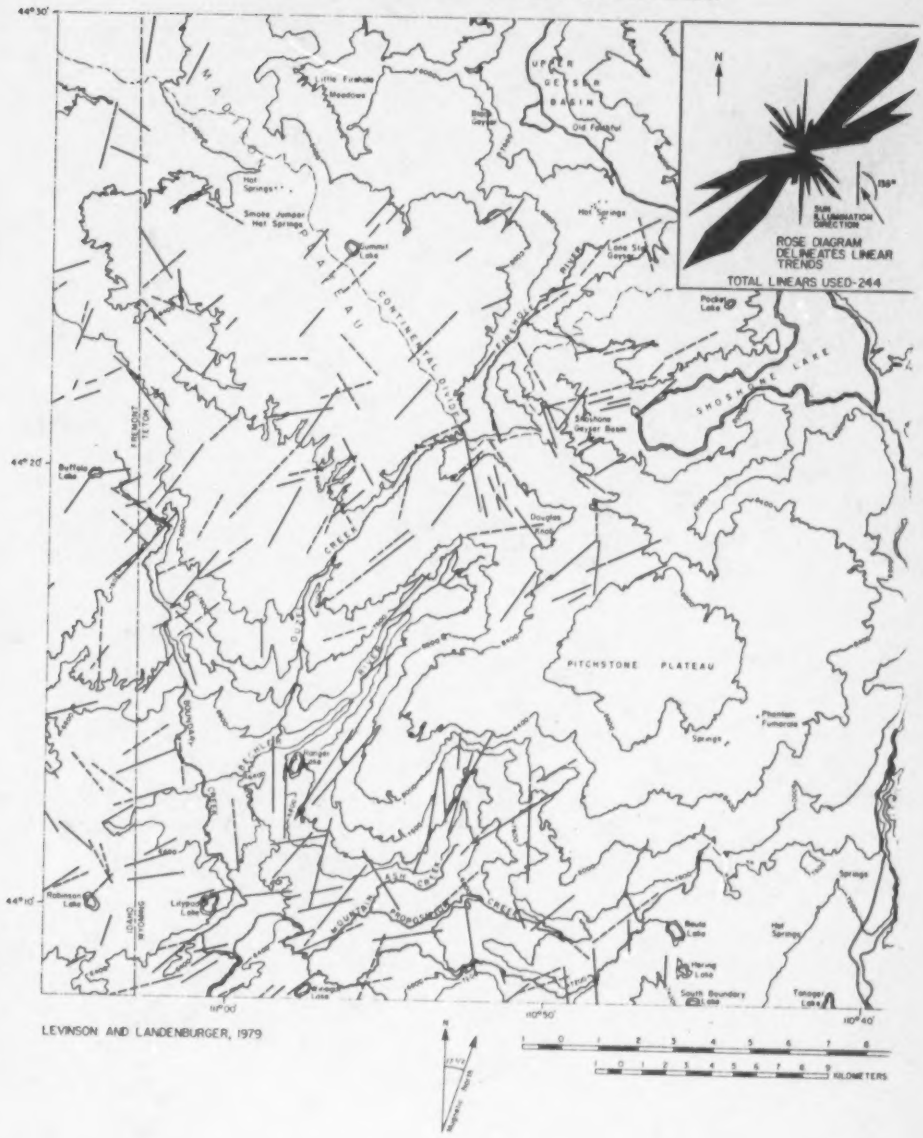


Figure 6. LANDSAT RBV image (30178-17302, 3 August, 1978, Subscene C) of the southwestern Yellowstone Park area which was interpreted for structure.

LINEAR FEATURES MAP OF SOUTHWESTERN YELLOWSTONE NATIONAL PARK
INTERPRETED FROM LANDSAT RETURN BEAM VIDICON IMAGERY



LEVINSON AND LANDENBURGER, 1979

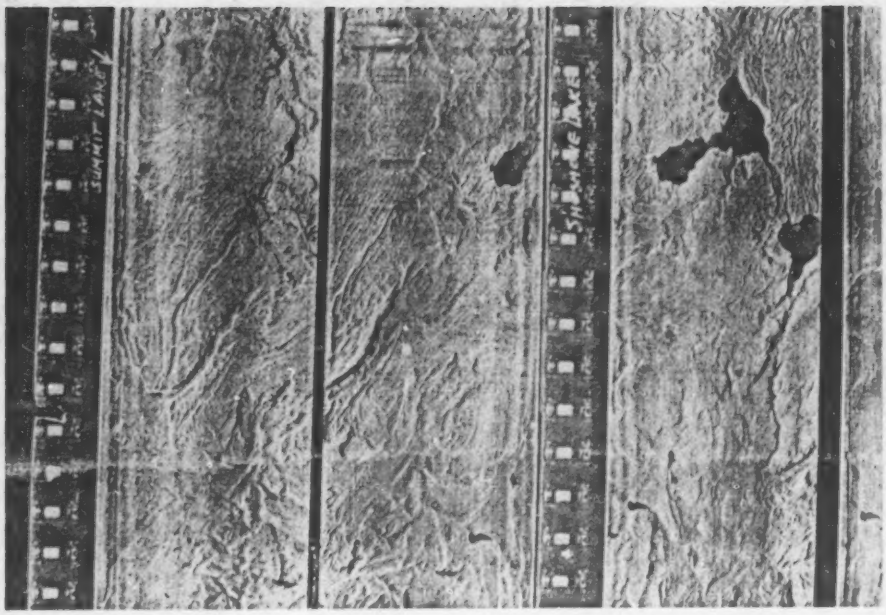
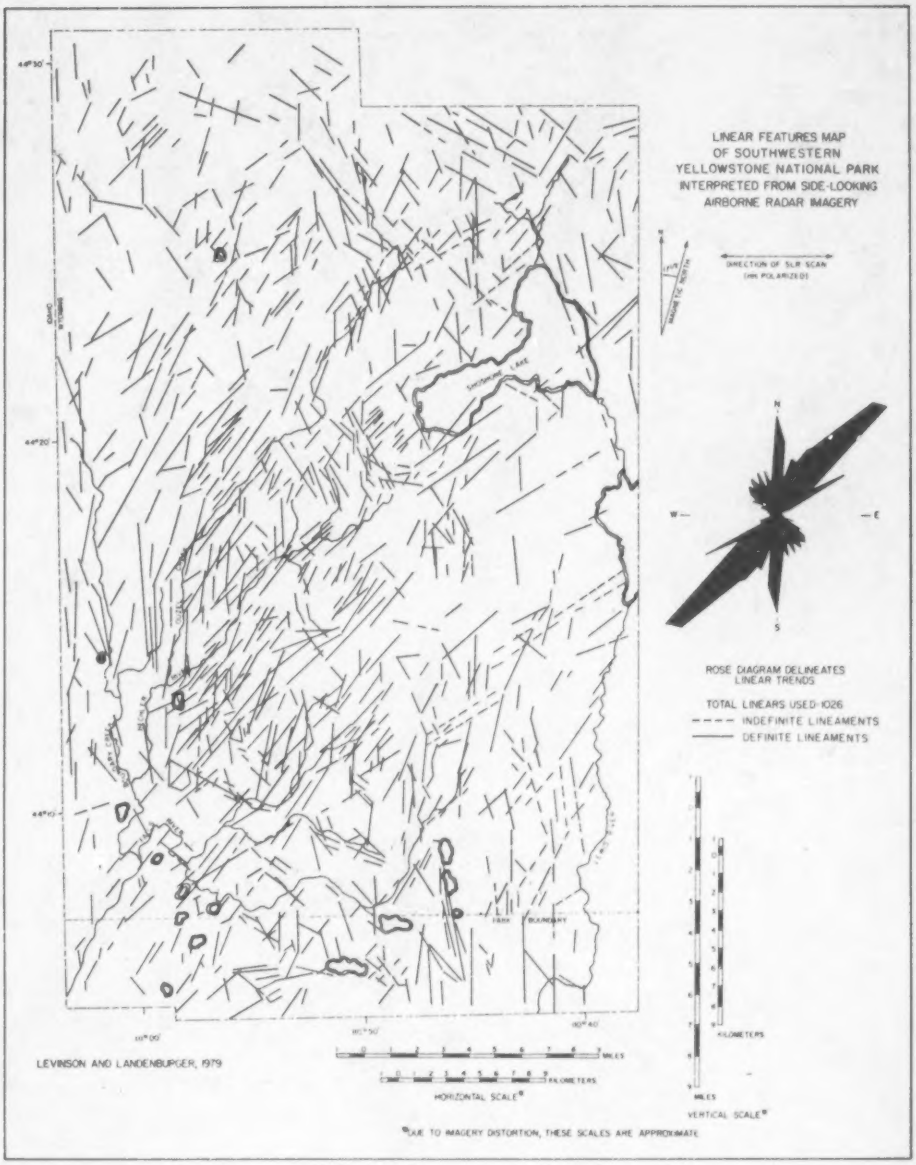


Figure 8. Side-looking Radar (SLR) imagery used for interpretation of linear features. Topographic features are enhanced by low-angle illumination. Water bodies appear black. Note overlap of rows and changes in direction of illumination.


LINEAR FEATURES MAP
OF SOUTHWESTERN
YELLOWSTONE NATIONAL PARK
INTERPRETED FROM SIDE-LOOKING
AIRBORNE RADAR IMAGERY
DIRECTION OF SLR SCAN
(ON POLARIZED)
N
W
E
S
ROSE DIAGRAM DELINEATES
LINEAR TRENDS
TOTAL LINEARS USED-1026
INDEFINITE LINEAMENTS
DEFINITE LINEAMENTS
44°30'
44°20'
44°10'
110°00'
110°50'
110°40'
LEVINSON AND LANDENBURGER, 1979
MILES
KILOMETERS
HORIZONTAL SCALE*
VERTICAL SCALE*
*DUE TO IMAGERY DISTORTION, THESE SCALES ARE APPROXIMATE

DISCUSSION

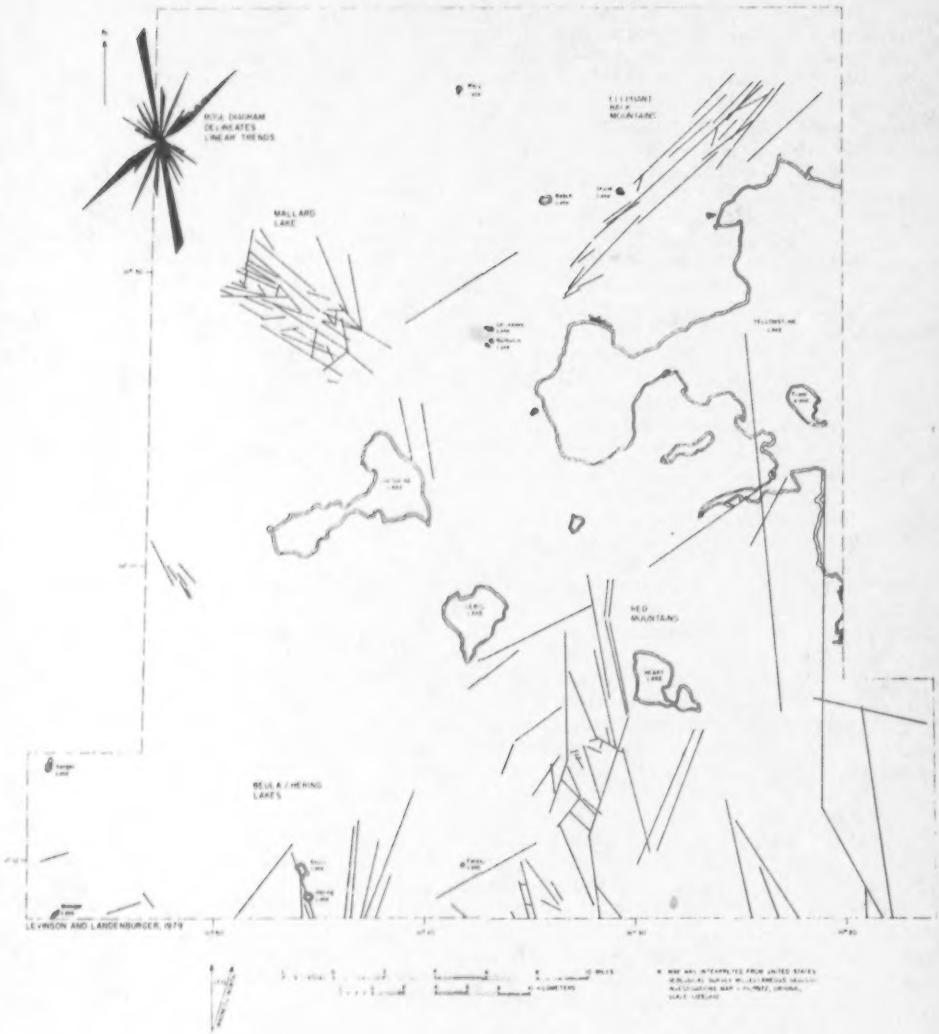
The rose diagrams (Figs. 7, 9) represent a length-weighted summation of all linear features on each map. They were compiled by measuring the total length of all linear features which trend the same direction (within five degrees of azimuth). Curvilinear elements were included by summing the chord of the arc with the other linear features. The values derived by summing the lengths of linear features and chords thru each five degrees of azimuth were then plotted around a central point with the magnitude of each value represented by its distance from the central point. This method of plotting the azimuth/length data of linear features yields a "rose diagram" in which the longer spikes indicate the direction of the most abundant linear features. The rose diagram allows for easy comparison of trends on the maps. If we assume that the linear features interpreted from the LANDSAT RBV imagery and the SLR imagery represent possible faults, or fracture systems, we can compare them to mapped faults and structural trends by comparing the rose diagrams.

A third linear features map (Fig. 10) was compiled from published geologic data (U.S. Geological Survey, 1972, a, b) for comparison with the linear features interpreted from imagery. Comparison of these maps was accomplished by comparing the rose diagrams which were constructed for each of the linear features maps (Fig. 7, 9).

Two major trends are evident in the rose diagram of mapped faults (Fig. 10): 1) a northeast-southwest trend, and 2) a nearly north-south trend. The northeast-southwest trend is best expressed in the area of the Elephant Back Mountains. The features shown on Figure 10 lie mostly within the Yellowstone caldera, but parallel the structures of the Snake River downwarp which extends southwestward away from the Yellowstone volcanic center. The northeast/southwest trend is also quite evident in the rose diagram representing the LANDSAT RBV and SLR image interpretations; but, in these interpretations, the northeast-trending features are <u>not</u> confined to the area inside the Yellowstone caldera. These features could reflect deep-seated fractures associated with the Snake River downwarp, or they could represent radial faults or radial stream drainages which developed as the Yellowstone volcanic center was domed upward prior to collapse of the Yellowstone caldera. However, the fact that these northeast trending features parallel linear gravity anomalies mapped by Rambo and Blank (1969), leads one to suspect that at least some of them represent deep-seated structures. Two northeast-southwest trends are apparent in the LANDSAT RBV data. They are both very strong, and may be particularly evident because they trend almost perpendicular to the direction of the suns illumination (azimuth 137°) at the time of the LANDSAT overpass. However, both are real trends. One may represent structures associated with the Snake River downwarp, the other may represent radial structures associated with the Yellowstone volcanic center.

The north-south trending features are prominent in the Mallard Lake area, the Beula Lake, Hering Lake, and in the Yellowstone Lake area. North-south

LINEAR FAULTS MAP INTERPRETED FROM
GEOLOGIC MAP OF YELLOWSTONE NATIONAL PARK *



* MAP ADAPTED FROM UNITED STATES
GEOLOGICAL SURVEY MISCELLANEOUS GEOLOGIC
INVESTIGATIONS MAP I-1127, GRIVNA,
GALE, WELLAND

trending features are also present in the LANDSAT image interpretation and very strong in the SLR image interpretation. These features may be enhanced in the radar image by the east and west look direction of the radar system. The north/south trend parallels major structures in the Teton and Gallatin ranges, and may reflect deformation of the same period. The appearance of this trend in Yellowstone Park suggests that the north/south structural system may be continuous beneath the volcanic cover and has been active since the eruption of the Yellowstone volcanic rocks.

A third, less prominent, trend is seen in the LANDSAT image interpretation, and is evidenced by a series of northwest-southeast spikes in the rose diagram. This trend may represent a concentric fracture system associated with doming and collapse of the Yellowstone caldera, which is centered to the northeast of the study area. If the northwest-southeast trend is related to volcanism, it may represent fracturing over a shallow magma body (Truesdell and Fournier, 1976). These fracture systems have been active since the last volcanism in the region. They undoubtedly transect the shallow aquifers and provide conduits for movement of thermal waters.

The correlation between surface thermal activity and fractures is evident in the strong relationships between the locations of thermal anomalies and linear features. For example, the Smoke Jumper group of thermal springs lies along a ring fault which bounds the Yellowstone caldera on the southwest. Most other thermally active areas also lie along or near linear features. In this regard, the northeast/southwest-trending features are of greatest interest because they may provide a link between the Yellowstone and Island Park geothermal systems.

CONCLUSIONS AND RECOMMENDATIONS

Interpretation of thermal imagery of southwestern Yellowstone Park has indicated several thermally anomalous areas which probably represent previously unknown thermal activity. These areas should be field checked to verify the thermal features and supplement the inventory of thermally active areas in the area. Concentration of thermal activity along fractures and linear features demonstrates the role of geologic structure in controlling the movement of thermal waters. A northeast/southwest trend in the identified linear features indicates a potential link between Yellowstone and Island Park thermal areas, but we presently have no evidence for movement of thermal waters through this system. However, with this potential link, it is essential that development of the geothermal resources in the Island Park area proceed with caution. Thermal waters should be sampled and analyzed chemically to "fingerprint" separate systems and define interconnected systems. Investigative drilling and continuous monitoring of changes in thermal activity may be necessary prior to exploratory and developmental drilling.

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Senator WALLOP. The next witness is Dr. Bloomquist.

STATEMENT OF DR. R. GORDON BLOOMQUIST, GEOTHERMAL SPECIALIST, WASHINGTON STATE ENERGY OFFICE

Dr. BLOOMQUIST. I'm Dr. R. Gordon Bloomquist. I'm a geologist with the Washington State Energy Office, and I serve as chairman of the Washington State Interagency Geothermal Development Council.

The timely passage of legislation to streamline the leasing provisions of the Geothermal Steam Act of 1970, to increase the acreage limitation to 51,200 acres per State, to lower the unrealistically high royalty on nonelectric projects, and to set aside a portion of the acreage leased each year for public bodies, is essential if the Nation's geothermal resources are to be developed. The need for very early passage of such legislation cannot be overstated in light of our ever increasing need to lessen our dependence upon foreign energy sources.

That's why it's extremely important that this hearing be held and that the question of protection for our national parks be addressed. So, we are very interested in the provisions of the proposed legislation which are designed to increase leasing and development. We do believe the guaranteed protection of the national parks is necessary.

S. 669. the Geothermal Steam Act Amendment of 1981; and H.R. 4067, the Geothermal Steam Act of 1981, offer suggestions as to how such protection could best be provided. S. 1516, the Geothermal Steam Act of 1981, presently has no provision for providing such protection. If the committee should decide to pass S. 1516, we urge the committee to include measures to protect the national parks.

H.R. 4067 would establish buffer zones to protect the nationally significant thermal manifestations of Yellowstone and Lassen Volcanic National Parks. Leasing would be denied within these buffer zones except as stated in the bill. These provisions leave no room for flexibility in modifying the established buffer zones upon the receipt of information which would indicate it's safe to do so. Nor would these provisions allow for obtaining additional scientific knowledge concerning the resource potential of these areas or its developability.

Senate bill 669 would provide protection for thermal manifestations through rulemaking which would create a list of nationally significant geothermal features and buffer zones to protect those features within our national parks. S. 669 would also allow for leasing within the buffer zones established if the Secretary of the Interior can determine that exploration activities will not have a foreseeably significant adverse affect on these nationally significant geothermal features.

The provisions of S. 669 appear to be much more flexible than those of H.R. 4067 in terms of studying the extent of the buffer zones and allowances of leasing within such buffer zones.

However, S. 669 places the burden of determining the extent of the geographic zones outside the boundaries of national parks and monuments where development of geothermal resources may adversely affect nationally significant thermal features upon the Secretary of the Interior. Likewise, the Secretary would be required by S. 669 to make a determination as to which areas within the buffer zones may be leased and to what extent exploration and development will not have foreseeably significant adverse affects on the thermal features of the park.

Such determinations by the Secretary could only be made through an extensive research program conducted by the U.S. Geological Sur-

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vey at taxpayers' expense. If such a research program were not initiated due to manpower or budgetary constraint, the development of geothermal resources in these areas could be hamstrung indefinitely, and could result in protracted judicial proceedings.

We strongly favor the adoption of legislation which will provide adequate protection to the nationally significant thermal manifestations of our national parks. Such legislation should, however, be flexible enough so as to neither hamstring the geothermal industry nor place undue burden upon the Secretary of the Interior.

We favor legislation which would provide for a fixed 15-mile wide buffer zone around Yellowstone National Park and a 1-mile wide buffer zone along the southern boundaries of Lassen Volcanic and Rainier National Parks.

The legislation should, however, allow the Secretary of the Interior to issue geothermal leases within the established buffer zones provided that the lessees within the area be required to implement monitoring programs approved by the U.S. Geological Survey to detect any significant adverse affects on the nationally significant thermal features of the national parks. The Secretary must also have the authority to order an immediate cessation of activity any time it is determined by the U.S. Geological Survey, through the monitoring system, that exploration, development, or production activities within the buffer zone are likely to cause significant adverse affects on the nationally significant thermal features and mitigating measures are not possible.

The mitigating measures would be to eliminate the effect before they would reach the park, not after they had already reached the park.

The adoption of the fixed buffer zones, the allowance for leasing within the buffer zones, the requirement for establishing monitoring programs at the expense of the developer, and the right of the Secretary to order an immediate cessation of detrimental activities will strengthen the authority and provide the flexibility the Secretary of the Interior needs in order to insure that adequate protection be provided to our national parks while allowing for a determination of the resource potential near those parks and whether or not that resource potential shall be safely developed.

I thank you very much, Mr. Chairman, for letting me testify today. And I'll be happy to answer any questions.

Senator WALLOP. Thank you very much, Dr. Bloomquist.

Ms. Street-Martin?

STATEMENT OF LEAH STREET-MARTIN, GEOTHERMAL SPECIALIST, IDAHO DEPARTMENT OF WATER RESOURCES, DIVISION OF ENERGY

Ms. STREET-MARTIN. Thank you, Senator Wallop and Senator Melcher. My name is Leah Street-Martin. I am a geothermal specialist working for the Idaho Department of Water Resources, Division of Energy. I'm glad that I have this opportunity to address this committee concerning S. 1516.

Geothermal energy is a viable alternate energy resource that is abundant in the Northwest. However, the cumberson leasing procedure has hampered the exploration and utilization of geothermal energy. For example, Republic Geothermal, Inc., has lease applications filed on Big Creek Hot Springs. This is near Salmon, Idaho.

Noranda Mining Co. has been interested in working with Republic on an electrical plant at Big Creek for their nearby cobalt mine. Until the leases are issued, no exploration of the resource will be conducted, thus delaying Noranda's decision whether or not geothermal can meet the energy requirements of their operation.

Lease applications filed in January 1974 are still waiting to be processed. No end users can put together projects until the leases are issued and the exploration is done. Exploration is further hampered by the lack of general geologic information of geothermal resources in Idaho. Most of the geologic work that has been done concerns mining potential.

Even though the Idaho Department of Water Resources and USGS have been working to understand the geothermal resources and potential of the State, more geologic work needs to be done. Passage of S. 1516 will streamline the leasing process, thus enabling more Federal land to be leased in a timely manner.

On August 12, 1981, 12 geothermal experts, mainly from the Pacific Northwest, met in Seattle, Wash., to discuss current geothermal legislation. At that time S. 1516 was carefully studied because it was strongly felt that the Geothermal Steam Act of 1970 needed to be amended and that S. 1516 was the best legislation for this purpose. A copy of the suggested changes decided upon at this meeting is found in appendix I of this testimony.

Yellowstone National Park and other parks with thermal manifestations are the subject of great concern when considering the development of geothermal energy around the borders. Buffer zones surrounding the park borders have been proposed.

In S. 669 a variable buffer zone is suggested. This would be time consuming as well as subject to court litigation. For example, it would take months, even years to establish this zone. And when it is established, it could be appealed.

A 15-mile buffer zone is proposed in H.R. 4067, and a buffer zone is not dealt with in S. 1516.

If a buffer zone is deemed necessary by the USGS, it should be a fixed zone and not variable as suggested in S. 669. Leasing should be allowed within the zone with strict guidelines.

When the Secretary of the Interior issues these leases, it would be required of the lessee to monitor with the USGS and significant adverse effects on Yellowstone National Park. If it is found that the development is adversely affecting Yellowstone, the operations will be terminated immediately.

This information obtained through the monitoring programs would help the Secretary to modify the buffer zones as well as enhance the geologic understanding of the area. When the buffer zone is established, the surrounding areas will be able to be leased and geothermal exploration can begin. All of the lease applications in the Island Park area are waiting for such a decision. And most of these applications are miles away from the park border.

It is imperative that S. 1516 be passed at this time. Leases need to be issued to further geothermal exploration and utilization. Because of the unknown structure of the Yellowstone thermal area, a fixed buffer zone provides a workable solution for the development of this potential resource without harming the national park.

Thank you.

[Attachment to Ms. Street-Martin's prepared statement follows:]

APPENDIX I

SUGGESTED CHANGES TO S 1516

Sec. 6. Section 5(a) of the Act is amended to read as follows:

"(a) a royalty of not less than 10 per centum or more than 15 per centum in the case of electrical generation, and beginning not before January 1, 1990 a royalty of not less than 5 per centum or more than 10 per centum in the case of nonelectric utilization, of the amount or value, as utilized, of steam, heat, or other form of energy derived from production under the lease and sold or utilized by the lessee or reasonably susceptible to sale or utilization by the lessee.".

Sec. 10(A). The act is further amended by adding the following subsection after 15(c):

"(d)(1)(A) When the Secretary issues geothermal leases within a fifteen-mile-wide buffer zone around Yellowstone National Park, the leases shall be subject to modification under subparagraph (C).

"(B) When the Secretary issues geothermal leases within a one-mile-wide buffer zone along the southern border of Lassen Volcanic National Park, the leases shall be subject to modification under subpararagraph (C).

"(C) When the Secretary issues geothermal leases within the buffer zones established in subparagraphs (A) and (B), he shall require lessess to implement monitoring programs to detect any significant adverse effects on the nationally significant thermal features of Yellowstone or Lassen Volcanic National Parks. The Secretary may use information obtained through operation of such monitoring programs to modify the buffer zone established in subparagraph (A) around Yellowstone National Park and the buffer zone established in subparagraph (B) around Lassen Volcanic National Park. If at any time it is determined that exploration, development, or production activities on a lease within the buffer zones established in subparagraphs (A) and (B) are likely causing significant

adverse effects on any nationally significant thermal features within these parks, and mitigating actions are not possible, the Secretary shall immediately order a cessation of the activities causing the effects.".

"(2) Any action seeking judicial review of a decision of the Secretary pursuant to this subsection may only be brought within sixty days following the date the decision of the Secretary is announced and made public. Any action shall be barred unless a petition is filed within the time specified. Any such petition shall be filed in the appropriate United States district court. Notwithstanding the amount in controversy, such court shall have jurisdiction to determine such proceedings in accordance with the procedures hereinafter provided, and to provide appropriate relief. Any such proceeding shall be assigned for hearing at the earliest possible date, and shall have jurisdiction to grant any injunctive relief against the issuance of any permit, lease, or other authority pursuant to this Act except as a part of a final judgment entered in a case involving claim filed regarding this section.".

Sec. 11. Section 23 of the Act is amended by adding after subsection (b) the following:

"(c) Where the Secretary finds it in the public interest, the Secretary is authorized, ~~subject to section 15(c), to issue permits for the use of geothermal resources in lands administered by him for any noncommercial application without requiring a lease or compensation therefor. No such free use permit may be issued for the purpose of generating electricity in any amount.~~ and directed, pursuant to such regulations as he shall promulgate, to grant at no cost a permit for use of a geothermal resource to the surface owner or lawful occupant of lands subject to this Act, if the use of the geothermal resource is directed by such person in a residence, farm, or small business property, does not involve any generation of electricity, does not involve sale of the resource in commerce, does not involve

commercial development of the resource, and involves only relatively small quantities of such resource. The use of the geothermal resource pursuant to such a permit shall not be inconsistent with any lease issued pursuant to this Act prior to the grant of the permit. Any lease issued subsequent to the grant of such permit shall, to the maximum extent practicable, not be inconsistent with such permit. The granting of a permit pursuant to this section shall not be subject to the requirements of section 102(2)(C) of the National Environmental Policy Act".

Sec. 11(A). Section 24 is amended by designating the present provisions as subsection (a) redesignating (a), (b), (c), (d), (e), (f), (g), (h), and (i), as (i), (ii), (iii), (iv), (v), (vi), (vii), (viii), and (ix), and by adding the following:

"(b) The Secretary shall make a decision on any lease application within one hundred eighty days after the filing of such application.

"(c) The Secretary shall make a decision on any permit to conduct drilling of exploratory or development wells within ninety days after the filing of such applications. The Secretary shall make a decision on a complete application to conduct development activities within one hundred eighty days of application.

"(d) The Secretary may for good cause extend the period for a decision on any permit or lease application for an additional period determined to be reasonable in specific cases, but not to exceed ninety days. If the need for such an extension is anticipated, the Secretary shall notify, in writing, the applicant and the Governor of the state within which the application was filed, a minimum of thirty days before the expiration of the inital time period. indicating the reason for the extension and the projected time to complete action on the application. In the event of any such extension---

(i) the payment of rental shall be suspended for the period of the extension; and

(ii) the running time of the lease shall be suspended for the ninety days or one

hundred eighty days, as the case may be, plus the period of the extension.

(iii) the Secretary shall be required to report annually to congress on all applications where timelines were not met or where a negative decision was rendered, stating the reason for not meeting such timelines or reason for a negative decison.

Suspensions as established in subparagraphs (i) and (ii) shall not include any delay resulting from a failure on the part of the applicant to satisfy the requirements for an application.

"(e) A lease application shall be reviewed and an initial report prepared and forwarded to the lease applicant within sixty days of the filing, indicating the results of the initial review, what disposition is proposed, and the projected time to complete action on the application.

"(f) A permit application, pursuant to a lease, shall be reviewed and an initial report prepared and forwarded to the lessee within sixty days of filing, indicating the results of the review, what disposition is proposed, and the projected time to complete action on the application.

"(g) The Secretary shall establish requirements for diligent operations which shall require that a plan of operations for exploration shall be filed within three years of the issuance of a lease. The diligence requirements shall also provide that drilling commence no later than two years after the approval of such plans or two years after a drilling permit has been approved, whichever is later, or the lease shall be terminated by the Secretary. The Secretary may provide for the aggregation of diligence requirements on lease tracts within a geothermal prospect. The running time of the diligence requirements established in this subsection shall be suspended for periods of unreasonable delay caused by a lessee's inability to obtain state or Federal permits (with the exception of permits issued by the Department of the Interior) through no fault of the Department.".

Senator WALLOP. Thank you very much. Senator Melcher?

Senator MELCHER. You used a term guarantee, Dr. Bloomquist. You mean that pretty solidly?

Dr. BLOOMQUIST. Yes; most definitely.

Senator MELCHER. Absolutely?

Dr. BLOOMQUIST. Yes.

Senator MELCHER. Well, then, how do you measure significantly adverse effects on the thermal features of the park?

Dr. BLOOMQUIST. Well, I think as stated earlier that any effect, detrimental effect to the resource of the park would be an adverse effect. Lowering of pressure up to the geysers, lowering the water table causing a diminish in flow of the hot springs.

Senator MELCHER. Well, what I'm suggesting is that significant adverse effects mean that something is wrong. You may have one idea and others may have a different idea on what significant adverse effects mean. What do you mean by it?

Dr. BLOOMQUIST. Well, any effect.

Senator MELCHER. Any effect? Any adverse effect?

Dr. BLOOMQUIST. Yes.

Senator MELCHER. Would lowering the temperature of the Madison 1° be an adverse effect?

Dr. BLOOMQUIST. I think so, yes.

Senator MELCHER. OK. That narrows it down; but you don't seem to get to this guaranteeing part before the activity. Your guarantee term doesn't apply to establishing the guarantee before the action is taken.

Dr. BLOOMQUIST. I think that by establishing a monitoring program such as what was talked about by the USGS, that you would—there is no such thing as an absolute guarantee; but that the chances would be diminished to the point where it's a very typical type of activity. I think that if the monitoring program that would monitor any pressure changes, any changes in hydrologic between the park and any development would be detected before it would reach the park; and therefore, no effect would be brought into the park.

Senator MELCHER. You would be satisfied with a monitoring coinciding with the leases?

Dr. BLOOMQUIST. Yes.

Senator MELCHER. The lease activity and the lease development by the lessees?

Dr. BLOOMQUIST. Yes.

Senator MELCHER. All right. Now, what about the State lands that are intermingled in Island Park? Aren't there some State lands there?

Ms. STREET-MARTIN. Yes, there is.

Senator MELCHER. Very many?

Ms. STREET-MARTIN. No.

Senator MELCHER. Is there any leasing activity on the State lands?

Ms. STREET-MARTIN. There is some activity at this time, but to the best of my knowledge exploration has not begun.

Senator MELCHER. Are there any leases issued by the State of Idaho?

Ms. STREET-MARTIN. Yes, there are a few.

Senator MELCHER. And how close are those State leases to the border of the park?

Ms. STREET-MARTIN. To the border of Yellowstone Park?

Senator MELCHER. Yes.

Ms. STREET-MARTIN. They are mainly in the Island Park area and not near the——

Senator MELCHER. I'm sorry, I should have said the Island Park area.

Ms. STREET-MARTIN. OK.

Senator MELCHER. I didn't include that in my question.

Ms. STREET-MARTIN. They aren't that close.

Senator MELCHER. Are they within 3 miles?

Ms. STREET-MARTIN. I wish I had my map here. I could show you exactly where they are.

Senator MELCHER. Page 167 of the EIS, which may not be up to date, shows 12,895 acres of State lands leased in the Island Park area. And it looks to me like the closest are about 8 miles from the park's border. Does that sound about right?

Ms. STREET-MARTIN. Uh-huh.

Senator MELCHER. So, what you're really speaking of, primarily in your testimony, is not the State's lease in the Island Park area. You're talking about the whole area?

Ms. STREET-MARTIN. Yes.

Senator MELCHER. All right. You feel that if the buffer zone is established under any formal legislation, even if it's a 15-mile buffer zone, that leasing should occur within the buffer zone?

Ms. STREET-MARTIN. Yes.

Senator MELCHER. So the point of the buffer zone is just for special guidance, not for——

Ms. STREET-MARTIN. Yes.

Senator MELCHER [continuing]. Absence of leasing and development?

Ms. STREET-MARTIN. Yes sir. And also it was mentioned earlier it would have to be a high roller developer to go into that area.

Senator MELCHER. Then perhaps there is no urgency at this time to, as far as this particular area is concerned adjacent to Yellowstone.

Ms. STREET-MARTIN. Well, what I meant by the high rollers is if you go into the 15-mile buffer zone it would be the burden of the developer to pay for the monitoring of wells. In a normal exploration, in a normal area where geothermal leases have been issued, it is the burden of the developer to pay for the exploration himself. I would like to see this bill passed so we can get some leasing activity occurring in a more expeditious manner than it has been in the past.

Senator MELCHER. It is true, though, that it is not known how deep the wells would be or how much geothermal development there would be?

Ms. STREET-MARTIN. Well, as I tell the people that come into my office asking me about the geothermal potential of their land, no one is going to know until they drill that well what the temperature is, what the flow is, how, at what depth they are going to—I can hypothesize at what depth; but there is no guarantee and no one knows until that well is drilled.

Senator MELCHER. So then you use the term "a high roller" more in a sense of being willing to spend more money for a well to pay for the

monitoring required than the likelihood of finding geothermal resources.

Ms. STREET-MARTIN. Yes, to pay for the monitoring.

Senator MELCHER. And do you have any idea what the monitoring would cost?

Ms. STREET-MARTIN. No, I don't.

Senator MELCHER. You just feel it would be quite expensive?

Ms. STREET-MARTIN. Well, drilling a well isn't cheap. For example, the State of Idaho just drilled a well. It's about 3,000 feet deep, and it cost $350,000. So, we're looking at a considerable chunk of money just to drill a well, let alone putting any kind of a system on it. So, it would be more expensive for a company to go into that area.

Senator MELCHER. Thank you very much.

Senator WALLOP. Dr. Heasler, I haven't had a chance to glance through your statement. I really appreciate it. It's going to be very useful information to me with regards to the rest of the State. It looks like there is some pretty high potential.

Dr. HEASLER. I can definitely say that, and that is one of the purposes of that article, is to inform you and other members of the subcommittee as to the potential in Wyoming and to give an idea of temperature, depth, and that sort of thing.

Senator WALLOP. Do you have any working knowledge of how the present leasing provisions are hindering or enhancing these projects, or are there other economic reasons——

Dr. HEASLER. Perhaps the main reason why there is not a lot of development in Wyoming, we're looking at low to moderate temperature resources. That means primarily less than 200° F. Mostly less than 300. That's not hot enough for commercial generation of steam. So, what we're looking at is direct heating purposes, things that can be used in greenhouse, things like that. The town of Thermopolis is considering an economics look to heat the entire town on thermal water there.

Also, the leasing procedure in Wyoming is, at best, unknown at this time. They say it will be considered on a site-by-site basis. Issues are being addressed by State Senator Deimer True and other people.

Senator WALLOP. Dr. Bloomquist, is there a desire, an expressed desire in leasing applications that surround——

Dr. BLOOMQUIST. Yes. We've had both the southern, western and northern borders pretty well covered by leasing applications. And the Forest Service has come out with a statement saying they would allow leasing in these areas right up to the park boundary, and feel that the USGS will administer the leases. So that no, I think we would still feel that it would be necessary to have the 1-mile buffer zone on the southern part of the park, basically to strengthen their hand in being able to set the monitoring system and to put up front that any leasing in there is going to have to have that extra burden upon them. And also, his knowledge that he will be shut down if any adverse effect is taking place.

Senator WALLOP. Is it your knowledge that anything exists up there or closer?

Dr. BLOOMQUIST. No, not at all. We have drilled two wells 500-foot deep last—well, about 2 years ago within, say, a half a mile of the park boundary in the southern boundary, and one in the northern boundary. And that's basically the only temperature data that we

have. All of those wells turned out to be in very strong groundwater and very little temperature was gained.

Senator WALLOP. Has an EIS or assessment been compiled?

Dr. BLOOMQUIST. As I said, the forest supervisors in both cases have said that they would allow leasing up to the boundaries. Leasing has not occurred yet; but some should be offered some time in January of this year.

Senator WALLOP. Can I ask each of you how you would react, assuming that we come down to a political decision right now, with regards to proceeding with leasing around Yellowstone Park and Island Park, whether it be a buffer zone of 15 miles or what have you, is the remaining interest—and obviously, it would be in Idaho State, so I might want to direct my question to you—is the remaining interest that we do proceed with 15 or 18 or something like that, to get the other leasing problems out of the way?

Ms. STREET-MARTIN. Yes.

Senator WALLOP. I think that may very likely be.

The emotions run very high in the Senate on the basis of how to resolve emotional—that in and of itself has a thermal potential that is pretty high. So, assuming that we couldn't do anything about that potential, it would be your suggestion that we do proceed anyway?

Ms. STREET-MARTIN. Yes.

Senator WALLOP. How anxious is the State of Idaho to have a geothermal development in that Island Park area, and do they view that as an energy resource that is needed presently in the State?

Ms. STREET-MARTIN. Our State is looking at any kind of energy, alternate energy source. We are looking at geothermal, more hydropower to offset our requirements for either coal-fire plants or a nuclear plant in Idaho.

Senator WALLOP. This is your preference, to either of those?

Ms. STREET-MARTIN. Yes. And other alternate sources that I mentioned.

Senator WALLOP. Yes.

Ms. STREET-MARTIN. We would like to see more geothermal development occur. We feel that it is a very viable resource; but again, we really don't know about the Island Park area, what it could produce or couldn't produce until exploration has begun.

Senator WALLOP. Does Boise still receive a percentage of residential heat from thermal resource?

Ms. STREET-MARTIN. You're going to be sorry you asked that question.

Boise has two geothermal projects. The wells are drilled. We are waiting now for the engineering and design procedures to be completed. The well I mentioned cost $350,000. That is to heat the eight buildings around the capitol. The capitol is included. Thus, the name the Capitol Mall Project was given to it.

The second heating district is Boise Geothermal, which is a private entity working with the city of Boise. And they essentially have taken over the Warm Springs Water District and will be heating more residential homes as well as buildings, businesses. They are looking for business because they are, naturally, the greater user of heat.

And so, yes, Boise is still being heated and even more so.

Senator WALLOP. I'm not sorry I asked that question.

Ms. STREET-MARTIN. I'm just very excited by that project.

Senator WALLOP. Well, listen, I am much appreciative to all three of you for being here. It has taken most of the week, and I know that is what it has taken. So, I appreciate your time and interest in coming here.

Thank you.

The last panel is Bill Cunningham of the Wilderness Society, Bruce Hamilton of the Sierra Club, and Cliff Merritt of the Wilderness Alliance.

It is my understanding that Elizabeth Horsch may mail her statement to the committee. She was unable to be here today.

Bill?

STATEMENT OF BILL CUNNINGHAM, NORTHERN ROCKIES REGIONAL REPRESENTATIVE, THE WILDERNESS SOCIETY

Mr. CUNNINGHAM. Thank you, Mr. Chairman.

Senator Wallop, Senator Melcher, I'm Bill Cunningham of Helena, Mont., Northern Rockies regional representative for the Wilderness Society, which includes the States of Wyoming and Montana within my region.

During the past 2 weeks I've discussed this issue with a number of Montana and Wyoming conservationists, and I feel that my remarks here today represent concerns of many people in this two-State region who are vitally concerned about the potential impact of geothermal development in Yellowstone and other geothermal features.

I want to first of all commend the leadership that both of you have exhibited and are exhibiting, as evidenced by today's hearing, to put together legislation that will insure the protection, not merely mitigation but protection of the unique thermal features of Yellowstone National Park. We are very appreciative for this leadership, and we stand ready to assist your efforts in any way possible.

I believe I want to begin my remarks by indicating that geothermal resources have the potential to significantly contribute to our energy needs in an environmentally acceptable manner. In this sense the Wilderness Society supports the general goal of exploring for and developing our Nation's geothermal resources.

The emphasis of my testimony concerns the effects of the proposed legislation on the national park system, the national wilderness preservation system, Bureau of Land Management Wilderness study areas, congressionally mandated wilderness study area lands recommended for wilderness under the U.S. Forest Service RARE II program, and RARE II further planning areas.

We believe, Mr. Chairman, that any geothermal legislation should include strong safeguards to preclude any adverse effects of geothermal leasing on our irreplacable national park system.

Now, I should point out that our concern centers mainly on the effects of exploration and development on hydrothermal features such as geysers rather than the other thermal features that have been mentioned here today.

Referring to section 124 of S. 669, as I read that section, the intent is to prevent geothermal leasing in areas that are adjacent to national parks and monuments where such leasing and development might adversely affect the geothermal resources in the parks and monuments.

Now, there is no such provision in S. 1516.

We support generally section 124 of S. 669; but we fear that the specific language of this section does not go far enough to insure protection.

I would like to suggest a series of several specific revisions and additions to the legislation.

First, we believe that the Secretary of the Interior should be required to designate protective zones adjacent to all national park system units where there are any geothermal features. The zone would be defined based on studies by the U.S. Geological Survey and the National Park Service and establish wide enough to insure protection of geothermal features in the park unit involved.

Second, the Secretary should prohibit from issuing leases in these protective zones unless he makes a finding based upon sound technical studies by the U.S. Geological Survey and the National Park Service that there would be no adverse effect on geothermal features in the park system unit.

Incidentally, we feel that the House language that was proposed from the 96th Congress is generally adequate in this area. And we would suggest that this language be referred to in drafting such a provision. And I attach a copy of this language in my statement.

Third, there should be a requirement that any leases issued in such a protection zone must contain a stipulation that exploration and that exploration and/or production shall be totally precluded at any time it is determined that such activities may adversely impact park geothermal features of the unit involved.

Fourth, to require lease activities to be closely monitored by the U.S. Geological Survey and the National Park Service to detect potential adverse effects on units of the park system.

Fifth, we believe that a no leasing zone should be designated around Yellowstone National Park that extends at least 20 miles from the park perimeter, which would include all of the Island Park caldera.

Now, generally, we would be leery of a fixed zone because of the impossibility of precisely defining the influence area here; but the 20-mile figure would include all the Island Park caldera.

Sixth, we would like to see designated a no leasing zone that extends at least 5 miles from the perimeters of Lassen Volcanic National Park and Mount Rainer National Park. These parks having been originally established in part because of the unique geothermal features which they exhibit.

Last, provisions should be made to prohibit Federal loans, grants or licenses for geothermal exploration or development in no leasing zones, in protective zones designated by the Secretary or non-Federal lands within units of the park system.

Now, certainly, this question of potential adverse impact does extend beyond Yellowstone; although, most assuredly, much of the concern does center on Yellowstone Park. But I am attaching to my statement as appendix B a listing of the 20 national park units which contain known geothermal features, according to the National Park Service.

I would like to comment on the BLM study areas since the proposed legislation does address the areas.

We believe there is no need for any special language concerning geothermal leasing or exploration in BLM wilderness study areas. The Federal Land Policy and Management Act permits geothermal leases

to be issued in BLM wilderness study areas and geothermal exploration is permitted.

The geothermal activities are specifically permissible in WSA's under the Energy Management Policy. The policy provides for exploratory drilling and even for new temporary access runs in WSA's as long as they do not permanently impair the wilderness values.

According to the BLM, all applications for geothermal exploration activities in wilderness study areas have been approved under this policy. So, again, in light of the ongoing policy, the ongoing process, the existing provisions that are made, we see no need that any special language be inserted for the study areas.

I would like to comment on the Forest Service for the further planning areas and the study areas which are closely related.

We do oppose geothermal leasing in Forest Service further planning areas and congressionalyl mandated wilderness study areas unless the leasing is conditioned to insure full protection of the wilderness option for the area which, of course, is the primary purpose for that type of designation.

Section 13(A) of S. 1516 does not provide this necessary full protection, and is thus unsatisfactory.

The Forest Service put many of the RARE II roadless areas into further planning because of the need for more minerals data, including geothermal potential, before making the recommendation for wilderness or nonwilderness. Some of the data about potential or lack of potential can be obtained through exploration by private parties holding geothermal leases. However, unless carefully stipulated, geothermal leasing will preempt the opportunity for either the Forest Service or the Congress to decide that a further planning area or congressional WSA should be preserved in perpetuity as wilderness. Leases should be issued in such areas only when accompanied by stipulations authorizing the Forest Service to deny exploration or production plans that have unacceptable impacts on wilderness character of these areas. Otherwise, the lease by its terms guarantees full development rights, the wilderness preservation option becomes meaningless. In this case, Congress as well is deprived of the right to study and possibly add areas as units of the wilderness system.

For leasing to be useful in data gathering while not precluding wilderness options, there must be stipulations agreed to by the lessee that authorize the Forest Service to deny exploration or production activities that would impair wilderness values. The so-called further planning stipulation currently used by the Forest Service is not adequate. It allows only the postponement, not the denial, of developmental activity.

What is needed instead is a stipulation similar to that devised by the Bureau of Land Management which clearly establishes that there are no automatic rights to develop. Under such leases, the agency retains the full option to recommend for wilderness because it can turn down plans of operation that impair wilderness character.

We, therefore, recommend that the bill direct the Forest Service to issue geothermal leases in further planning areas and congressional WSA's only with a wilderness protection stipulation of the nature used for BLM wilderness study areas. This will insure adequate opportunity for exploration while not precluding Congress to exercise the option of wilderness designation.

A word about the national wilderness preservation system.

Section 13(B) of S. 1516 amends the Wilderness Act of 1964 to open the national forest wilderness system to geothermal leasing and development. We strongly oppose this provision.

Geothermal development is inherently incompatible with preservation of wilderness values. And herein, I believe, there is a similarity with the current national concern over oil and gas leasing in wilderness areas, which both Senator Wallop and Senator Melcher have exhibited national leadership. We believe that this similarity is striking. Unlike oil and gas, however, which I don't want to go into in any detail here, but just to say that unlike with oil and gas, with geothermal we do have an opportunity to get ahead of the game insofar as protecting wilderness areas is concerned. Under current interpretation, there is some ambiguity as to whether these added after 1970 would be open for geothermal leasing. And it's the opinion of the solicitor that such units would be open for leasing. Therefore, creating a policy split within the wilderness system with regard to those units before 1970 and those after 1970. And we can see no reason to continue such contradictory policy with units of the national wilderness system.

The national forest wilderness system represents only 1 percent of our national land area. And it's clear that they cannot make any significant contribution to our geothermal energy production, even if there was evidence that any of these wilderness areas are likely to have real geothermal potential.

We believe that our national wilderness areas have been designated by Congress in recognition of their unique and irreplacable natural, historical, scientific, and ecological values. These areas should not be sacrificed for development unless we have no other alternative. Fortunately, because of conservation and the development of other renewable energy sources, there are alternatives to risking the loss of our irreplacable wilderness heritage.

Accordingly, we recommend that the bill specifically provide that geothermal leasing is totally prohibited in units of the national wilderness preservation system. In order to maintain congressional option, such prohibition should also extend to those areas recommended to wilderness and those to national forest systems.

In addition, we feel that the seven-point process recommended for the national park system should also apply to all units of our national wilderness preservation system insofar as protective zones adjacent to the wilderness areas are concerned.

As a final point, the Secretary should be directed to give high priority to the acquisition of either fee or an interest sufficient to preclude geothermal energy development, of all inholdings of private land within units of the national park and wilderness systems containing thermal features.

Similarly, high priority should be given to exchange of any State or municipally owned public lands within units of the park and wilderness systems for the same purpose.

In conclusion, the Wilderness Society believes that the integrity of the resources of the units of the national parks and wilderness systems is of sufficient national importance to provide protection from the potential harm of geothermal energy development. We urge their

incorporation in any amendments to the Geothermal Steam Act of 1970.

Thank you again for the opportunity to testify before the subcommittee on this important legislation. I very much appreciate the opportunity to submit my statement.

And, Mr. Chairman, I have a letter from the Colorado Open Space Council, and I would like to request that it be accepted for submission.

[The prepared statement of Mr. Cunningham follows:]

THE WILDERNESS SOCIETY

Northern Rockies Regional Office
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STATEMENT OF BILL CUNNINGHAM, REPRESENTING THE WILDERNESS SOCIETY BEFORE THE U.S. SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES, SUBCOMMITTEE ON PUBLIC LANDS AND RESERVED WATER, DECEMBER 2 1981, ON S. 1516 and S. 669.

Mr. Chairman, I am Bill Cunningham of Helena, Montana, Northern Rockies Regional Representative for The Wilderness Society. The Society is a national conservation organization of some 50,000 members dedicated to sound long-term multiple use management of our public lands for the benefit of the Nation. I greatly appreciate this opportunity to present testimony on S. 1516, the "Geothermal Steam Act of 1981," and S. 669, the "Geothermal Steam Act Amendments of 1981."

Geothermal resources have the potential to significantly contribute to our energy needs in an environmentally acceptable manner. In this sense, The Wilderness Society supports the general goal of exploring for and developing our Nation's geothermal resources.

The emphasis of my testimony concerns the effects of the proposed legislation on the National Park System, the National Wilderness Preservation System, Bureau of Land Management Wilderness Study Areas (WSA's), Congressionally-mandated WSA's, lands recommended for wilderness under the U.S. Forest Service RARE II program, and RARE II Further Planning Areas.

THE NATIONAL PARK SYSTEM

It is essential, Mr. Chairman, that any geothermal legislation include strong safeguards to preclude <u>any</u> adverse effects of geothermal leasing on our irreplaceable National Park System.

"In wildness is the preservation of the world." - Thoreau

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To illustrate the problems that can result from geothermal exploration and development I offer the following excerpt from a June 8, 1979 Department of Interior letter of comment on the final Island Park EIS:

"Although commercial geothermal development in other areas of the world have had profound effects on geyser basins, the draft statement makes no mention of this. Geyser Valley in New Zealand was totally destroyed as a natural discharge area when the Wairakei geothermal area was developed. Before this action, Geyser Valley ranked fifth among the major geyser areas of the world. In addition, production from Wairakei also affected another thermal area thought to be independent with no connection at depths which would simultaneously affect the pressure of both systems. The Beowawa Geysers area of Nevada was once second to Yellowstone on the North American Continent in the 1940's and 1950's when geothermal exploration was begun. Wells were drilled and permitted to discharge, but not converted to commercial use; by 1961 all springs and geysers had ceased flowing. Similar destruction of the geyser area of Steamboat Springs, Nevada, occurred after geothermal exploration between 1950 and early 1960's. Of ten world-ranked geyser areas, only three including Yellowstone, are essentially undisturbed; four of ten have been adversely affected by man's activities; and at least three of these major areas and several minor ones have seen the total destruction of their geysers. Thus, the statement must clearly point out that, unless geothermal exploration and development is very carefully planned, monitored, and controlled, irreversible damage to the geothermal regime at YNP is a distinct possibility."

It is important to point out that most of our concern centers on the effects of exploration and development on hydrothermal features, such as geysers. As Donald E. White of the U.S. Geological Survey's branch of field geochemistry noted "In general, we cannot exploit the geothermal energy of an area and also preserve its geysers." He further concluded that "any changes, once made, are probably irreversible within our lifetimes, and perhaps not even in hundreds of years."

Section 124 of S. 669 intends to prevent geothermal leasing in areas adjacent to national parks and monuments where such leasing could adversely affect geothermal resources in the parks and monuments. S. 1516 has no such provision.

While we support the general intent of Section 124 of S. 669, the specific language of the section does not go far enough to ensure protection.

We recommend the following specific revisions and additions to the legislation:

(1) To require the Secretary of Interior to designate protective zones adjacent to all National Park System units where there are any geothermal features. The zone would be defined based on studies by the U.S. Geological Survey and the National Park Service and established wide enough to ensure protection of geothermal features in the park unit involved.

(2) To prohibit the Secretary from issuing leases in these protective zones unless he makes a finding based upon sound technical studies by the U.S. Geological Survey and National Park Service that there would be no adverse effect on geothermal features in the park system unit.

I am enclosing an appendix A, a copy of House language from the 96th Congress which would require a Secreterial finding of no adverse impact and which we recommend for addition to the legislation. Please note that this provision was generally supported by at least one industry representative (Mr. Rudy Buchwald of SUNEDCO) at the October 27, 1981 subcommittee hearing in Washington, D.C.

(3) To require that any leases issued in such a protection zone must contain a stipulation that exploration and that exploration and/or production shall be totally precluded at any time it is determined that such activities may adversely impact park geothermal features.

(4) To require lease activities to be closely monitored by the U.S. Geological Survey and the National Park Service to detect potential adverse effects on units of the Park System.

(5) To designate a "no leasing" zone around Yellowstone National Park that extends at least 20 miles from the park perimeter to include all of the Island Park Caldera.

(6) To designate a "no leasing" zone that extends at least 5 miles from the perimeters of Lassen Volcanic National Park and Mount Ranier National Park. There are numerous scattered geothermal leases pending in the three national forests which surround Mt. Ranier National Park. Some of these, such as those pending in the Packwood District of the Gifford Pinchot Forest may pose a grave threat to the Longmire Hot Springs and other thermal features in the Park. Very little research has been done in this area and the point is that no one knows for sure what the effects may be of exploring and developing these adjac[illegible] leases.

(7) To prohibit Federal loans, grants or licenses for geothermal exploration or development in "no leasing" zones, in protective zones, designated by the Secretary, or on non-Federal lands within units of the Park System.

To illustrate that the potential adverse impact of geothermal exploration and development extends beyond Yellowstone Park, I am attaching to my statement as Appendix B a listing of the 21 National Park System units with known thermal features of national significance.

BLM WILDERNESS STUDY AREAS

There is no need for any special language concerning geothermal leasing or exploration in BLM Wilderness Study Areas. Consistent with the Federal Land Policy and Management Act of 1976 (FLPMA), geothermal leases are issued in BLM Wilderness Study Areas and geothermal exploration is permitted. Section 603 of FLPMA specifies that study areas are to be managed so as not to impair their wilderness values. BLM has issued a detailed policy for managing these study areas. This "Interim Management Policy" already fully provides for the purposes sought in S. 1516 and S. 669:

> Study areas are open to issuance of new geothermal leases, and BLM has been issuing such leases. Up through 1980, the Bureau had issued a total of 134 leases in wilderness study areas and leases are continuing to be issued in response to applications. These leases are issued in response to applications. These leases are issued with a wilderness protection stipulation that makes it clear that exploration or production are permissible so long as they do not impair wilderness suitability of the study area.
>
> Geothermal exploration activities are specifically permissible under the interim management policy. The policy provides that exploratory drilling and even new temporary access roads may occur in WSA's so long as they do not permanently impair wilderness values. All applications for geothermal exploration activities in wilderness study areas have been approved under this policy according to the BLM.

FOREST SERVICE FURTHER PLANNING AREAS/CONGRESSIONAL WSA's

The Wilderness Society opposes geothermal leasing in Forest Service further planning areas and Congressionally-mandated WSA's unless the leasing is conditioned to ensure full protection of the wilderness option for the area. Section 13 (A) of S. 1516 does not provide this necessary full protection and is thus unsatisfactory.

The Forest Service put many of the RARE II roadless areas into Further Planning because of the need for more minerals data, including geothermal potential, before making the recommendation for wilderness or nonwilderness. Some of the data about potential or lack of potential can be obtained through exploration by private parties holding geothermal leases. However, unless carefully stipulated, geothermal leasing will pre-empt the opportunity for either the Forest Service or the Congress to decide that a further planning area or Congressional WSA should be preserved in perpetuity as wilderness. Leases should be issued in such areas only when accompanied by stipulations authorizing the Forest Service to deny exploration or production plans that have unacceptable impacts on wilderness character. Otherwise, if a lease by its terms guarantees full development rights, the wilderness preservation option becomes meaningless. In this case, Congress as well is deprived of the right to study and possibly add areas as units of the Wilderness System.

For leasing to be useful in data-gathering while not precluding wilderness options, there must be stipulations agreed to by the lessee that authorize the Forest Service to deny exploration or production activities that would impair wilderness values. The so-called "further planning" stipulation currently used by the Forest Service is not adequate; it allows only the postponement, not the denial, of developmental activity. What is needed instead is a stipulation similar to that devised by BLM which clearly establishes that there are no automatic rights to develop. Under such leases, the agency retains the full option to recommend for wilderness because it can turn down plans of operation that impair wilderness character.

We thus strongly recommend that the bill direct the Forest Service to issue geothermal leases in further planning areas and Congressional WSA's only with a wilderness protection stipulation of the nature used for BLM wilderness study areas. This will ensure adequate opportunity for exploration while not precluding Congress of the option to designate wilderness.

NATIONAL WILDERNESS PRESERVATION SYSTEM

Section 13(B) of S. 1516 amends the Wilderness Act of 1964 to open the National Forest Wilderness System to geothermal leasing and development. We strongly oppose this provision.

Geothermal development is inherently incompatible with preservation of wilderness values. If a wilderness area were opened to geothermal development, by definition, wilderness would cease to exist in light of the substantial facilities required for geothermal production. Furthermore, it is obvious that our National Wilderness System

could not make any significant contribution to geothermal energy production, even if there were evidence that any wilderness areas were likely to have real geothermal energy potential. The National Forest Wilderness System represents only 1 percent of our national land area. Surely, such a small amount of land base cannot be relied on as a significant source for meeting our Nation's energy needs. Finally, our national wilderness areas have been designated as such by Congress in recognition of their unique and irreplaceable natural, historical, scientific and ecological values. These areas should not be sacrificed for development unless we have no other alternative. Fortunately, because of conservation and the development of other renewable energy sources there are alternatives to risking the loss of our irreplaceable wilderness heritage.

Accordingly, we recommend that the bill specifically provide that geothermal leasing is totally prohibited in units of the National Wilderness Preservation System as well as in areas recommended for wilderness in the RARE II process.

In addition, the 7-point process recommended above for the National Park System should also apply to all units of our National Wilderness Preservation System.

As a final point, the Secretary should be directed to give high priority to the acquisition, of either fee or an interest sufficient to preclude geothermal energy development, of all inholdings of private land within units of the national park and wilderness systems containing thermal features. Similarly, high priority should be given to exchange of any state or municipally-owned public lands within units of the park and wilderness systems for the same purpose.

In conclusion, The Wilderness Society believes that the integrity of the resources of the units of the national parks and wilderness systems is of sufficient national importance to provide protection from the potential harm of geothermal energy development. We urge their incorporation in any amendments to the Geothermal Steam Act of 1970. Thank you again for the opportunity to testify before the Subcommittee on this important legislation. Please insert this statement into the official hearing record.

appendix A

HOUSE

SEC. 16. Section 15(c) of the Act is amended by adding at the end thereof the following: "With respect to lands referred to in subsection (c)(1), the Secretary shall identify within one hundred and twenty days after enactment of the Geothermal Steam Act Amendments of 1979, and publish in the Federal Register, a list of significant thermal features located on such lands, and shall update such list periodically as necessary. The Secretary may not issue geothermal leases on Federal lands in proximity to such identified features except to the extent that he determines, based on the best geological, hydrological, and other relevant information obtainable, that activities pursuant to a geothermal lease on such Federal lands will have no potential for causing adverse effects on such thermal features. No department or agency of the United States shall assist by loan, grant, license, or otherwise in the exploration for or development of geothermal resources in proximity to the identified features listed pursuant to this paragraph unless the Secretary determines, in accordance with the provisions of the preceding sentence, that such assistance will have no potential for causing adverse effects on such thermal features.".

appendix B

Description of Surface Thermal Features within National Park System Areas

Hot Springs National Park (Arkansas)

The park was established in 1832 specifically for the protection and use of hot springs for bathing and other therapeutic purposes. The boundaries contain hot springs as well as a significant portion of the water system which naturally recharges the springs. The hot springs are the reason visitors come to the park.

Lassen Volcanic National Park (California)

Volcanic and associated thermal features (steam vents) are found throughout the park and are the major visitor attractions. The volcanic features were the reason for the original presidential proclamations and subsequent congressional consolidation/expansion.

Sequoia National Park (California)

The park has one small warm spring, approximately 7 miles inside the boundary, near a geological fault. The feature was not a prime purpose for establishment, although it is illustrative of the park's geologic history and the warm spring does receive visitor use.

Hawaii Volcanoes National Park (Hawaii)

Volcanic and thermal features were the prime reason for park establishment and visitor use. Two active volcanoes, a variety of volcanic features, and other thermal features such as steam vents and hot pools are located throughout the unit.

Yellowstone National Park (Idaho, Montana, and Wyoming)

Of the world's great thermal areas, Yellowstone has the most extensive assemblage of thermal features anywhere. A major reason for the creation and visitor use of the area, the thermal features are located throughout the park, although the better known features (such as Old Faithful) are mainly in the southwest section. Unlike most of the world's great thermal areas, Yellowstone still retains its natural features. Yellowstone's caldera is enormous, over 1,000 times larger than Mount St. Helens'.

Lake Mead National Recreation Area (Nevada)

This area contains two warm springs (pools) about 2 miles inside the boundary, below Hoover Dam. Both areas are used by segments of the visiting public for recreation; in earlier times local Indians are thought to have made use of the springs as well.

Big Bend National Park (Texas)

The park has three warm springs or pools adjacent to the Rio Grande. One is associated with a turn of the century bath house on the National Register of Historic Places, another provides potable water for the Rio Grande Village developed area, and the third is the habitat of gambusia gaigei, a rare and endangered species of topminnow.

Mount Rainer National Park (Washington)

Mount Rainier, whose protection and use is a major reason for this park's establishment, is a dormant volcano with associated active thermal features found in 3 areas of the park. Active steam vents are found on the summit, warm springs in the southeast at Ohanapecosh, and warm mineral springs in the southwest at Longmire; all, especially Longmire and Ohanapecosh, have a history of visitor uses. In winter, Ohanapecosh springs are snow-free and thus a gathering place for elk; other elk leave the park for lower elevations in winter.

Olympic National Park (Washington)

The park contains two warm springs, both associated with past and current visitor use. One site (Sol Duk River) was the most popular tourist site in the Northwest at the turn of the century; the Service has just assigned this area to a concessioner. This spring also alters the river's pH, leading to improved fish habitat. Both springs are illustrative of the volcanic history of this part of the Olympic Range.

Grand Teton National Park and John D. Rockefeller, Jr., Memorial Parkway (Wyoming)

The park has three warm springs, all associated with the block faulting of the Teton Range and illustrative of the area's geologic history. Two of the three areas are used by visitors for recreation: one near the southern entrance, the other on the east. The ecological dynamics of these warm springs are not documented. The parkway includes one warm spring inside the northern border. This warm spring is associated with volcanism and probably is part of the Yellowstone system. Once a concession site, this spring still receives visitor recreation use.

Alaska Areas

NOTE: Some surface thermal features which have been reported in the past to exist within the boundaries of the new areas have not been verified by staff. Nonetheless, if carried in the literature, they appear below. In addition, visitor use patterns have not been established or documented to some remote features in new parks.

Aniakchak National Monument and Preserve

This areas contains steam vents and hot springs within the perimeter of the Aniakchak caldera, in the middle of the unit. The prime purpose for the establishment and purpose of the area is volcanism and its relationship to the pioneer biotic systems. The volcano last erupted in 1931.

Bering Land Bridge National Preserve

The Sepentine Hot Springs are located near the area's southern boundary. The springs have a long history of use (by Natives, and notably during Gold Rush times), are still used, and are repeatedly referred to in the legislative history. Evidence of volcanism, one of the purposes of establishment, is located throughout the area, but the hot springs are the only known surface thermal feature. Pilgrim Hot Springs, a significant thermal source thought to be part of Serpentine's aquifer, is located over 50 miles away outside the boundary.

Denali National Park and Preserve

2 areas if we consider Denali NM and McKinley NP separately

Reported thermal features are three warm springs in the northen portion of the area--Courtney, Galcier, and Toklat--and reported gas venting along the Denali fault which has not been verified. Toklat, the better known feature, is mentioned in the legislative history. It is significant in that it causes an increased population of salmon and brown bear in the vicinity and it is illustrative of the mountain-building activities centering on Mount McKinley.

Gates of the Arctic National Park

The Arrigetch Peak grantitic pluton and the Mount Igikpak grantitic pluton are areas where the rock is slighly warm to the touch. Arrigetch and Igikpak are each important scenic areas already receiving comparatively high visitor use for their recreation and scenic features. The Reed River Hot Springs are near the southeastern boundary; apparently these springs have been used by Eskimo people for cooking, although the varying water temperature makes the springs unreliable.

Glacier Bay National Park

Lituya Bay Hot Springs are located in a fjord setting along the remote outer coast of the park. The park is located along the "Ring of Fire" and the spring is illustrative of the park's geologic history.

Katmai National Park

The prime purpose for establishment and visitor use of this area is its extensive and spectacular examples of volcanism. Numerous steam vents and hot springs are located between Mount Douglas and Mount Martin.

Lake Clark National Park and Preserve

Mount Redoubt and Mount Iliamna are active volcanoes (steam vents) located on the east side of the park. The protection of these volcanoes was among the purposes for the area's establishment.

Wrangell-Saint Elias National Park and Preserve

Warm springs are located on the map, but have not be verified to exist by park staff. Reported to be gas-charged springs, they are commonly known as "mud volcanoes." Mount Wrangell is an active volcano with steam venting. The most impressive mountain park in the System, the park was established to protect the mountains and associated ecosystems.

Yukon-Charley Rivers National Preserve

Two incompletely verfied warm springs are reported to exist within the area. The McCartney spring is reported to exist on the upper third of Flat Creek, and the Woodchopper carbonated spring is reported to be on the Woodchopper Creek. Further verification is required.

colorado open space council
2239 E. Colfax Ave., Denver, CO 80206 393-0466

December 10, 1981

Senator John Warner
Senator Malcolm Wallop
Senate Office Building
Washignton D.C. 20510

Dear Senators,

The Colorado Open Space Council is a coalition of envoronmental groups concerned about the preservation and wise use of our natural resources. Our member groups number thirty three and represent over 20,000 individuals.

We would like to comment on the proposed geothermal leasing bill which, as we understand it, could open National Forest Wilderness to geothermal development. In Colorado we are particularly concerned about two existing wilderness areas. Both Mount Zirkel, near Steamboat Springs and Lizard Head, near Telluride, have pending geothermal lease applications within their boundaries. Several other wilderness areas in the state may be in similiar situations in the future.

COSC opposes any legislation which would threaten the proven wilderness values of these areas. Particularly since we have yet to see evidence that wilderness areas contain significant geothermal resources. Our national resource of wild areas is shrinking and we must work to protect what is left.

Thank you for your consideration of these comments and I will look forward to hearing the outcome of this bill.

Best regards,

Larry Mehlhaff

Larry Mehlhaff
Director
Wilderness and Public Lands Project

cc: Senator Gary Hart
Senator Bill Armstrong

"Man belongs to earth, not earth to man"

Senator WALLOP. By all means we will include it in the record. Thank you for your statement.
Bruce?

STATEMENT OF BRUCE HAMILTON, NORTHERN PLAINS REGIONAL REPRESENTATIVE, THE SIERRA CLUB

Mr. HAMILTON. Thank you, Senator Wallop, Senator Melcher. My name is Bruce Hamilton. I'm the northern plains regional representative of the Sierra Club.

I'll be departing substantially from my written comments, and I request that they be added in entirety to the record.

At this time I would like to add our qualified support for most parts of the bill. We think there is a need to spurge geothermal development and in most cases it can be clean and renewable. But there is also need to proceed with caution.

The primary purpose of this here is to determine how to protect the irreplaceable hydrothermal wonders of Yellowstone National Park. There is more than just an academic question. Over 200 lease applications have been filed next to the park. The Forest Service in their study recommended some leasing in this area coupled with buffer zones, monitoring and the like. And the lease applicants have refused to accept this, in some cases have filed an appeal with the Forest Service. There clearly is an active interest on the part of certain parties in developing geothermal next to the national park.

The reason for concern is if, indeed, there is any kind of possible subterranean connection between the two areas. I have tried to read every available study I can on this. And I think the conclusion I reached is the same one that you two have reached, and that is it's basically inconclusive. We just don't know. We think we have a good idea, but we can't be sure.

And so the approach that was taken in the final EIS was taken by the Department of the Interior when they suggested certain stipulations be added to the leases. That was to allow some leasing and at the same time require monitoring, reinjection and the like, and retain the authority to shut it down if, indeed, they could find the adverse effects.

This is a seemingly cautious approach; but I still feel it is not proving anything. It sounds promising, but we are not absolutely sure that it will work. And I realize that's something we've been playing back and forth with, can you guarantee. And I think that is not too high a standard when we are talking about Yellowstone National Park. I don't really care whether the odds are 9 to 1 or 8 to 1. If there is a chance that they are going to be damaging Yellowstone National Park, we should not be proceeding.

This is really not an unfound fear. It has been mentioned earlier. You know, 7 out of the 10 world-ranked geyser fields have been adversely affected or destroyed. We have learned from the mistakes. We have learned what we have done wrong; but it is not clear to me that we have learned enough so we are absolutely sure how to do it right.

The lesson that I learned from the situation in Wairakei, they drilled in the geyser basin. And sure enough, they had the predicted result that there would be the adverse effect on the pressure there. But we also learned that 2½ miles away there was adverse effects, and no one predicted that. And somebody assumed that it wasn't going to happen and, indeed, it did happen. And we note the fact that it's only

2½ miles; but that happened to be the proximity of the two geyser basins. And if, indeed, they were 4 miles apart, there may have been an adverse effect as well.

So, you can't assume it will only affect 2½ miles away. It happens to be a case where we had two adjacent geyser fields, and there was the result.

What I learned from that experience is that the whole underground plumbing system of the Earth is far more complex than anybody can ever imagine, and that we don't know a hell of a lot. And that should be the lesson. Not what we did, you know, wrong, but how we can proceed from here.

So, now, we talk about reinjection, monitoring, and the like. And I hope during the course of this hearing record you will ask the questions of the experts, because clearly I am not one. But I have yet to see any substantial proof that reinjection and monitoring will work. You know, has it been done anywhere, or is this theory as well? You know, I would really like to prove these theories elsewhere then next to Yellowstone National Park. In my mind we should not be conducting a grand experiment there. And if, indeed, we can prove reinjection, monitoring, and everything else, works in other places, then we can start proceeding closer and closer to the national parks, perhaps. But at this point a 1- or a 2- or a 20- or a 40-mile buffer zone next to Yellowstone National Park, in my mind, is not sufficient. We need to be looking at any area that might foreseeably have a geological subterranean connection.

Senator McClure and others have expressed the position that there is no additional protection language necessary to make sure that the parks are adequately protected. I am strongly in disagreement. I would point to the situation in Lassen National Park in California, to point that out. There in Lassen they drilled in 1962 and again in 1978 within 50 yards of a geyser commonly known as Terminal Geyser. And this was all perfectly legal. It was a private holding within the park, and the Park Service was unable to put a stop to it. In one case they were not made aware of the fact that they had done it.

As Senator Melcher pointed out, we see State leases just west of Yellowstone National Park. There are also private leases. I'm aware of 24,700 acres of State and private leases. And I believe some go as close as 5 miles to the park. It may be closer to 8 as Senator Melcher described. Anyway, it's a significant problem, because even if there is not Federal leasing in this area, we still have the problem of what to do with the private and State holdings and the fact that they can develop as well. And there has been language suggested in trying to get a Federal handle on those to make sure those do not proceed as well; but I think you need to look at the lesson of the Lassen National Park.

I ask you to look beyond the boundary of Yellowstone. I am sure Huckleberry Hot Springs in the John D. Rockefellor National Park, in my mind, these areas are also equally nationally significant. They are areas that are important for wildlife, important for recreation, reasons why people come to the national parks. I think it would be very narrowminded to set up a system that would protect Yellowstone or Yellowstone and Lassen and leave these others out.

The test that has been in some of the language in the bills has to be a significant geothermal source. And you're only looking at that

and seeing if you have a significant adverse effect. And it's just right for litigation. And on top of that, you know, I would have a hard time—Kelly Warm Springs is fairly insignificant when you compare it to Old Faithful; but people love to go out there, and it is a major mecca from the park. Even though from a national perspective, it wouldn't be on anybody's list.

I want to raise another issue that really hasn't been addressed, but it's something that is a direct concern to your subcommittee. And that is a question that I think is festering in this, and it's really come to a head in the case of oil and gas. And I'm sure that Senator Wallop and others are also aware of it.

And that is the question of whether or not an agency maintains—excuse me, whether or not when you issue a lease you are granting the right to develop. Agencies maintain that a lease is just an issuance of paper, and that at any time in the future when they come in with an operating plan, at that particular time if things don't look right, if there is going to be an adverse effect, you can say no. As a matter of fact, as late as September 9, Secretary Watt issued a memo saying that he felt that the lease issuance was just paperwork, and that they would do detailed environmental assessments after the issuance; but would wait for the operating plans. That makes sense from the financial standpoint, because very few leases are actually developed, either in the oil and gas field or the geothermal field. But the problem is that the agencies may not maintain the legal authority to say no later on when the operating plan comes.

And Malcolm is all too familiar with the case of Caster where the Forest Service had issued a lease for oil and gas and then later on said, "Is there any way we can say no to development?" And the solicitors will find at that point we are stuck. And if you don't want to see the area developed, you should not have issued leases.

The agencies are now in the position of issuing leases, and they had what is called a CDS, which tries to set up this process where you can say no later down the road; however, this particular kind of stipulation is being challenged by the industry. Leases with the stipulation have been rejected. And recently a Forest Service appeal in the Long Valley area in California also came up with the opinion that when you issue the lease is when you have granted the development right.

Now, there is a slight difference between geothermal and oil and gas, in that it is more of a stage process. There still is the question of whether or not that is granted, and I would urge the Congress and this committee to look very seriously at that and come up with some way to resolve it so the public, groups like the Sierra Club, are not caught in this catch-22. If you need to formally declare, it is the policy of the United States that you can set these types of policies after the leases have been issued or conversely you need to turn around and direct the agencies to do the environmental impact statements at the least issuing stage and consider the options of no leasing at that stage. Otherwise, I'm afraid that we are going to end up leasing all the land, including mostly environmentally sensitive areas, and then the leases may be overturned in the legal process. And the court may come up that it is not something that the court and Congress desires.

Thank you for this opportunity to testify, and I would be glad to address any issues that I raised in my written statement.

[The prepared statement of Mr. Hamilton follows:]

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STATEMENT OF BRUCE HAMILTON

NORTHERN PLAINS REPRESENTATIVE, SIERRA CLUB

BEFORE THE

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE,

PUBLIC LANDS AND RESERVED WATER SUBCOMMITTEE,

ON S. 1516 AND S. 669

GEOTHERMAL STEAM ACT AMENDMENTS OF 1981

December 12, 1981

Casper, Wyo.

Senator Wallop and other distinguished Members of the Subcommittee:

I am Bruce Hamilton, Northern Plains Regional Representative of the Sierra Club. On behalf of the Club and its quarter of a million members I would like to express our appreciation for this opportunity to testify here today on the proposed amendments to the Geothermal Steam Act of 1970 contained in S. 669 and S. 1516.

I especially want to express my thanks to Senator Wallop for organizing this field hearing in Wyoming. Wyoming has within its borders one of the most outstanding concentrations of hydrothermal features in the world in Yellowstone National Park. While the Congress refines its program to promote the development of geothermal energy we need to take every precaution to make sure that the delicate and poorly understood hydrothermal resources of preserves such as Yellowstone are protected in perpetuity.

The Sierra Club would like to express qualified support for most of the provisions in the legislation being considered today. Geothermal energy can provide a significant,

near-term, clean, renewable source of domestic energy. Its rapid development should be encouraged, consistent with environmental protection.

Detailed comments on specific aspects of the bills have already been entered into the record for the Sierra Club by Tim Mahoney in his Oct. 27, 1981 testimony before the Senate Energy and Mineral Resources Subcommittee and by Hamilton Hess in his Oct. 31, 1981 letter to Subcommittee Chairman John Warner. I have attached their statements to this testimony and will try to avoid repetition. Instead, I will focus on other important issues that also deserve your attention.

Some industry analysts suggest that we could be producing the energy equivalent of about 700,000 barrels of oil per day by the year 2000 from geothermal sources. The U.S. Government Coordinating Council predicts production of about one million barrels of oil equivalent by the year 2000 from geothermal sources. Clearly we are dealing with an energy resource that can put a significant dent in our nation's oil appetite--especially when coupled with a diligent energy conservation program.

But we should not rush blindly to develop all potential geothermal sites and we should recognize that geothermal development has many attendant environmental problems.

To date geothermal energy development is restricted to the utilization of naturally occurring underground reservoirs of hot water or steam. Such sites are limited in capacity and number and in most cases are depletable. Another problem is that these hydrothermal sites are often located in remote areas--far from the energy demand centers and in areas with exceptional natural, scenic and archeological values. Also, when underground reservoirs are exploited there can be an adverse effect on nearby hot springs, geysers and other natural thermal features. Serious air and water pollution problems can result from the release of toxic gases and chemical substances.

All this leads the Sierra Club to urge development with caution and to encourage more emphasis on those geothermal energy sources that can be developed independently of naturally occurring hydrothermal reservoirs.

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Specifically, we favor and encourage:

1. Non-electrical, direct heat uses of earth heat and geothermal fluids for space, agricultural, and industrial heating in situations and localities where naturally occurring hydrothermal features will not be degraded; and
2. The development of techniques for the extraction of heat contained at depth in dry hot rock, in sedimentary basins, in geo-pressured systems, and in the earth's normal temperature gradients. Such developments would assist in avoiding some of the impacts and hazards of geothermal operations under present technology, would provide greater flexibility in project and facility siting, and would vastly extend the available earth heat resources.

This field hearing has been called with the primary purpose of addressing how best to guarantee that the irreplaceable hydrothermal wonders of Yellowstone National Park are not jeopardized by geothermal development of adjacent lands. This is not just an academic question. The U.S. Forest Service has received about 200 geothermal lease applications in the Island Park area of Idaho just west of Yellowstone. The proposed lease area is only 13 miles from Old Faithful and lesser known geysers and thermal features are as close as a quarter mile from the Island Park Known Geothermal Resource Area. The Forest Service, in its final environmental impact statement on the leasing proposal, proposed the adoption of strict standards, no lease zones, reinjection of extracted fluids and monitoring to guarantee protection of the park. Some of the lease applicants regarded the Forest Service decision as too stringent and filed an appeal. There is intense interest in developing right up to the boundary of the park.

This might not be too grave of a concern if there was firm scientific evidence that the hydrothermal features inside the park were not connected with the geothermal resource outside the park. We have yet to see the final word in this debate. From all the literature I have seen all that can be concluded is that we can not be sure that the two areas are separate--there remains a strong possibility of a subterranean connection.

There are those who are saying since we don't know that the two areas are connected we should allow exploration and development outside the park under very strict standards and with careful monitoring. If an adverse impact on the park is detected, authority would be maintained to shut down all exploration or development activities. We feel this seemingly cautious approach is not prudent enough. When we are talking about Yellowstone we are talking about an internationally-renowned center of geothermal activity. We should not gamble with the fate of the park, no matter how favorable the odds. As long as the remotest chance exists that the park could be adversely affected we should insist on no development.

The hearing record on these bills is already rife with references to the fact that seven of the world's ten top geyser fields have been destroyed or adversely affected by exploration and development. Beowawe Geysers in Nevada, once second only to Yellowstone on the North American continent, was destroyed by exploration alone.

These dramatic examples of destroying geyser fields are important to remember as we consider accelerating development. Some will try to dismiss these past incidents as examples of poor planning: in most cases the destruction occurred because drilling was allowed inside the geyser field itself. However, predicting the impact of drilling outside a known geyser area is a very inexact science. For example, in New Zealand geothermal development in the Wairakei area has caused an expected decline in reservoir pressure in the immediate area. However, what was unpredicted was that the Wairakei development would also silence the geysers in the adjacent and seemingly independent area known as The Spa, which was located one to four kilometers away. The lesson we must learn from this tragedy is that the earth's delicate plumbing system is much more complex than most people would care to admit. When it comes to understanding the intricate workings of the world's geothermal features we remain basically ignorant.

"The natural geysers of at least four different areas have become inactive, coinciding with geothermal exploitation," writes Donald White of the U.S. Geological Survey. "In general, we cannot exploit the geothermal energy of an area and also preserve its geysers."

Some will say sure we've done it wrong in the past but now we know how to do it right. Through a careful system of reinjection of fluids, buffer zones and monitoring we should be able to detect any adverse effect in time to correct any problem. This approach sounds promising, but has it ever been proven anywhere? When there are unpredictable natural fluctuations in hydrothermal features how can we be sure that the monitoring can pick up an unnatural adverse effect before it is too late? If an adverse effect is detected, are we sure that we can correct the problem or will irreversible damage result? Will the relatively small withdrawals that occur during exploration give us an indication of the impact of larger withdrawals during production? Will some of the adverse effects be noticeable only after several years so that the effects won't show up in the monitoring until a great deal of long term damage has been done? These unanswered questions give us pause. We are talking about conducting a grand experiment. The Sierra Club is firmly opposed to experimenting with Yellowstone National Park.

An arbitrary one or two or twenty mile buffer zone around Yellowstone is not an adequate answer to this potential threat. We need to study and identify all adjacent areas that might foreseeably be connected to the park and then insist on absolutely no leasing, exploration and development within those areas. If this means placing the entire Island Park Caldera off limits to leasing, so be it. The loss of lease revenues and the potential loss of some geothermal energy contribution are a small price to pay to guarantee protection of an irreplaceable wonder of the world.

Senator McClure and others have said that they would prefer no park protection language in the amendments you are considering today. S. 1516 has no park protection language. We firmly disagree with the contention that there are adequate provisions in existing law to protect the parks.

One only has to look at the case of Lassen Volcanic National Park in California to see how vulnerable the parks are. In 1962 the Park Service discovered that a private firm was drilling an exploratory well within 50 yards of Terminal Geyser on a private inholding. The well was completed and capped. In 1978, Phillips Petroleum, who had picked up the

private leases, cleared an area the size of a football field, redrilled the hole, capped it, and moved out--without any prior notification to the Park Service.

If this kind of activity can go on within an existing park and be deemed totally legal what protection does existing law afford the parks?

This illustration of what can happen on non-federal land is an important lesson to remember when considering legislative protection for Yellowstone. As of November, 1979, over 24,700 acres of state and private land in Idaho and adjacent to Yellowstone had been leased for geothermal development. One state section that has been leased is within five miles of the park boundary. At least 10,000 acres of state leased land is within 10 miles of the park. The bill passed by the Congress must contain language to make sure that the nation's parks aren't degraded by development of non-federal lands, too.

So far, I have limited my remarks to Yellowstone and the immediate threat of leasing and development on adjacent lands in Idaho. But I would urge the subcommittee not to get so engrossed in the crusade to save Old Faithful that you lose sight of the broader picture of other geothermal features equally deserving of protection.

For example, I am sure Senator Wallop is intimately familiar with Huckleberry Hot Springs in the John D. Rockefeller Memorial Parkway and Kelly Warm Springs in Grand Teton National Park. Neither of these popular thermal features are within Yellowstone and yet they are every bit as worthy of protection as the features in Yellowstone.

I was pleased to read that Sen. Wallop, Sen. Warner, Sen. McClure and Interior Sec. Watt had agreed that the Senate bill would establish "special statutory protections for the nationally significant thermal features of Yellowstone National Park." At the same time I was dismayed that the focus of the protection was going to be limited to the "significant" features of one park.

The park protection language in the House bill (H.R. 4067) is equally disappointing. It sets up inadequate buffer zones around parts of two national parks--Yellowstone and Lassen--and fails to acknowledge the existence of thermal features in other units of the National Park System.

In the last Congress, both of House-passed and Senate-passed bills had language to protect all park system hydrothermal features. This system-wide approach should be adopted by the subcommittee, the full committee, the Senate and the Congress.

In response to the anticipated passage of a bill in the last Congress the National Park Service came up with a list of thermal features in 21 units of the National Park System. From Hot Springs National Park in Arkansas to Hawaii Volcanoes National Park and Glacier Bay National Park in Alaska we feel these units are equally deserving of protection. In summary, all surface thermal features in all park system units are deserving of equal protection.

The question has also arisen about whether or not units of the National Wilderness Preservation System can and should be leased for geothermal development. Recently, Interior Solicitor William Coldiron issued an opinion that wilderness areas established prior to 1970 (the date of enactment of the Geothermal Steam Act) could not be leased, but any wilderness established after 1970 could be leased. We firmly disagree with this opinion. The 20-year grace period for mineral claimstaking and mineral leasing contained in section 4(d)(3) of the Wilderness Act did not allow for geothermal leasing since geothermal resources are not legally defined as minerals.

We hope that this issue does not have to be thrashed out in the courts. We urge the subcommittee and the rest of the Congress to clarify the issue by adding a provision that once and for all places wilderness areas out of bounds to geothermal leasing. We strongly oppose Section 13(b) of S. 1516 which amends the Wilderness Act to open the wilderness system to geothermal development.

Senator Wallop is well aware of the furor created in Wyoming when proposals to lease the Washakie Wilderness for oil and gas development surfaced earlier this year. I'm sure that opposition of equal intensity would rise over any efforts to lease wilderness for geothermal development. The spectre of oil field pump jacks, pipelines and access roads is bad enough--but imagine, if you can, a geothermal power plant in a wilderness? Such an industrial scene would be the antithesis of wilderness.

So far I have singled out national parks and wilderness areas. The Sierra Club's concerns do not stop there. Except where direct heat utilization for space heating of buildings and lodges is compatible with the primary preservation purposes, the Sierra Club opposes geothermal operations in the following areas:

1. Lands included in or adjacent to federal, state or local park systems or in wildlife refuges and management areas;
2. Areas known to provide habitat for rare or endangered species;
3. Areas designated as valuable for archaelogical remains;
4. Units of the National Wilderness Preservation System;
5. Units of the Wild and Scenic Rivers System;
6. Units of the National Trails System;
7. Areas reserved by the Secretary of the Interior or the Secretary of Agriculture for ecological, scenic, natural, wildlife, geological, educational, historical, or scientific value, including Primitive Areas, Roadless Areas, Natural Areas, and Pioneer Areas;
8. Areas of de facto wilderness under study by the Secretary of the Interior or the Secretary of Agriculture for reservation as part of one of the preservation systems listed above.

There is another festering issue in the geothermal arena that may well deserve Congressional attention and action so that the courts do not produce a result that is outside the intent of Congress. The issue I am referring to is whether or not a lease conveys the right to develop.

Federal land management agencies have held that leasing is not a significant federal action and that the government has the opportunity to do a full environmental impact statement and even go so far as to reject all development plans when a lease holder comes in and requests a permit to develop. This approach was recently codified in departmental policy when Secretary Watt issued a memorandum (Sept. 9, 1981) declaring that lease issuance was just "an exercise in paperwork" and that detailed environmental studies would

be delayed until the time when plans of operations were received.

This approach has been taken in the past by federal land managers who have attempted to add contingent development stipulations (CDS's) on geothermal leases. The CDS says, in effect, that the land management agency maintains the authority to say no to any development when a plan of operations is submitted.

However, it should be noted that these CDS's are being resisted by lease applicants. In Oregon, CDS leases have been rejected. In California, an appeal to the Chief of the Forest Service of leases in the Long Valley caldera lead to the conclusion that lease issuance conveys a develop right.

There is a classic "Catch 22" here for the public. The government says, don't worry, we'll do environmental impact studies at the development stage. However, the industry argues that the commitment to development is made at the lease issuance stage. The Sierra Club maintains that if development rights are conveyed at lease issuance, then an environmental impact statement should be done prior to lease issuance. We are concerned that thousands of acres of public land may be leased naively with a CDS attached only to have the stipulation thrown out by the courts leaving no protection for fragile lands. If the Congress approves of the agency policy of reserving the right to say no until the operation permit stage then I feel it is only fair to put this policy into law so that it cannot be overturned in the courts. Alternatively, the Congress should direct the agencies to prepare EIS's at the lease issuance stage and recommend no leasing in environmentally sensitive areas.

Thank you for this opportunity to present testimony. I would be pleased to work with the subcommittee to come up with specific language to address some of the problem areas I have delineated.

Senator WALLOP. Thank you, Bruce.
And Cliff Merritt, would you proceed?

STATEMENT OF CLIFTON R. MERRITT, EXECUTIVE DIRECTOR, AMERICAN WILDERNESS ALLIANCE

Mr. MERRITT. Thank you, Senator Wallop and Senator Melcher.

I want to express the American Wilderness Alliance's appreciation also for holding this important hearing on this critical subject in which millions of Americans are interested.

I'm going to try to summarize my prepared statement, and I ask that the prepared statement be made a part of the record in its entirety.

Senator WALLOP. It will be, and we appreciate your summary.

Mr. MERRITT. Thank you. I am Clifton Merritt, executive director of the American Wilderness Alliance.

Established in 1978, the American Wilderness Alliance is a national nonprofit organization dedicated primarily to promoting the conservation and wise use of the Nation's decreasing wildlands, wildlife habitat and wild river resources.

Our headquarters are located at 4260 East Evans, Denver, Colo., 80222.

The alliance supports the general objectives of promoting the orderly exploration and development of our Nation's geothermal resources; but in regard to S. 1516 and S. 669, the Alliance is concerned about certain provisions where they are absent. Because of the adverse impact that they could have on our unique national parks and wilderness areas, we feel that these bills should be amended to protect our national parks and wilderness areas from adverse impacts of geothermal energy development.

For example, the Geothermal Steam Act of 1970 does not protect national parks from possible adverse impacts of geothermal development outside the park boundaries. And in that connection we've already heard a great deal about the possible relationship of Island Park outside of Yellowstone National Park.

Also the 1970 act does not bar geothermal exploration and development on privately owned lands within units of the national park system. Amendments should take care of these deficiencies. Liberal buffer zones of no development would certainly help, and geothermal development should not be allowed in the holdings in national parks.

The American Wilderness Alliance is strongly opposed to the provisions of S. 1516, which would open national wilderness areas to geothermal leasing and development. We feel that wilderness and geothermal development and production cannot coexist. An amendment is needed to the 1970 act, in our judgment, prohibiting geothermal leasing in the national wilderness system.

Section 13(A) of S. 1516 allows geothermal leasing in Bureau of Land Management wilderness study areas. And Mr. Cunningham indicated, and we also feel, that this provision is superfluous. BLM wilderness study areas are already open to geothermal leasing and exploration under the Federal Land Policy and Management Act, and leasing is presently taking place.

Another provision in S. 1516; namely, section 13(A), authorizes geothermal leasing and exploration in national forest further planning areas. Further planning areas are being considered for a wilderness designation. The alliance feels that this provision must include, as well, authority for the Secretary of Agriculture to deny exploration or development if such activity would have unacceptable impacts on the wilderness character of a further planning area. Without this authority, the wilderness potential of the further planning area would be destroyed even before it was reviewed by the Forest Service, let alone acted upon by Congress.

A wilderness character protection provision like that used for BLM wilderness study areas is needed.

Mr. Chairman, we believe that the aforementioned changes will expedite legislation to promote the orderly and needed development of our country's geothermal resources without unnecessarily impairing our Nation's unique national parks and wilderness areas. We recommend their favorable consideration and adoption.

Thank you again for the opportunity to comment on this matter.

[The prepared statement of Mr. Merritt follows:]

Statement of Clifton R. Merritt
Executive Director
American Wilderness Alliance
before the
Senate Subcommittee on Public Lands and Reserved Water
regarding S. 1516 and S. 669
to Amend the Geothermal Steam Act of 1970
at Casper, Wyoming, December 12, 1981

Mr. Chairman and other distinguished Members of the Subcommittee:

I am Clifton R. Merritt, Executive Director of the American Wilderness Alliance.

Established in 1978, the American Wilderness Alliance is a national non-profit organization dedicated primarily to promoting the conservation and wise use of the nation's decreasing wildlands, wildlife habitat and wild river resources. The Alliance's headquarters are located at 4260 East Evans, Denver, Colorado 80222.

The American Wilderness Alliance supports the objective of promoting the orderly exploration and development of our country's geothermal resources. To this end, we have no objections to the general provisions of S. 1516 and S. 669.

However, we are concerned about the effect that certain provisions, or lack of them, in these bills would have on our national parks and wilderness areas. We believe that the measures should be amended to protect parks and wilderness areas from the adverse impacts that could result from geothermal energy development.

Specifically, while the Geothermal Steam Act of 1970 prohibits geothermal leasing within national park units, it does not protect the park units from exploration and development of their underground energy resources outside park borders. For example, geothermal drilling and development at Island Park in Idaho west of Yellowstone National Park could adversely affect Old Faithful and other outstanding geothermal features within Yellowstone Park. It is simply impossible to develop the geothermal energy resources of an area and at the same time preserve its geysers. This fact has been amply demonstrated in Nevada and in New Zealand and other places.

Also, the present 1970 act does not bar geothermal exploration and development on privately owned lands within units of the national park system.

Amendments to the 1970 act should adequately take care of these deficiencies. In other words, all lands within units of the national park system must be excluded from direct or indirect geothermal development. Zoning buffer areas around Yellowstone and other parks possessing thermal features as off-limits to geothermal activity could take care of indirect development threats.

We are adamantly opposed to amending the 1964 Wilderness Act --as Section 13 (b) of S. 1516 does--and open national forest wilderness areas to geothermal leasing and development.

Geothermal production entails considerable facilities, such as roads, pipelines and other structures. In our judgement, wilderness could not co-exist with geothermal production. National forest wilderness areas constitute only a very minor part of our total land acreage. It is not likely that geothermal production from national forest wilderness areas could make a significant contribution to the nation's energy needs. Promotion and development of safe, renewable sources of energy, such as solar, would be far more rewarding. The 1964 Wilderness Act was enacted by the Congress and the President "to secure for the American people of present and future generations the benefits of an enduring resource of wilderness." Section 13 (b) would, in effect, amend this policy. We respectfully urge adoption of an amendment to the 1970 act expressly prohibiting geothermal leasing in the National Wilderness Preservation System.

Section 13 (a) of S. 1516 allows geothermal leasing in Bureau of Land Management wilderness study areas. This is unnecessary. BLM wilderness study areas are already open to geothermal leasing and exploration under the Federal Land Policy and Management Act of 1976. The 1976 act provides that study areas are to be managed so as not to impair their wilderness values. Geothermal exploration is permitted under the BLM's Interim Management Policy. Drilling and temporary roads are allowed in wilderness study areas if they don't permanently impair wilderness values. Geothermal leasing and exploration are presently taking place in BLM wilderness study areas.

Section 13 (a) also authorizes leasing and exploration in national forest further planning areas. Further planning areas are being considered for a wilderness designation. We object to this provision unless it contains, as well, authority for the Secretary of Agriculture to deny exploration or development if such activity would have unacceptable impacts on the wilderness character of a further planning area. Without such authority, a lease guaranteeing full development rights could make the wilderness option null and void. A wilderness protection stipulation like that used for BLM wilderness study areas is needed.

Mr. Chairman, we believe that the aforementioned changes will expedite legislation to promote the orderly and needed development of our country's geothermal resources--without unneccessarily impairing our nation's unique national parks and wilderness areas. We recommend their favorable consideration and adoption.

Thank you for the opportunity to present these comments.

Senator WALLOP. Thank you very much, Cliff. Senator Melcher?

Senator MELCHER. Cliff, I just want to be sure that I understand what you mean by zoning buffer areas around Yellowstone.

Mr. MERRITT. We would——

Senator MELCHER. How big an area would it be?

Mr. MERRITT. We would on that, Senator Melcher, say that the buffer zones within which there should be no geothermal leasing development or production should include Island Park and some of these other areas that were mentioned here. I would say——

Senator MELCHER. A rather broad area?

Mr. MERRITT. In excess of 15 miles.

Senator MELCHER. All right. Thanks. I have no other questions.

Senator WALLOP. Bruce, I don't quarrel with you that the phrase is right for litigation, significant, either significant adverse effects or significant geothermal features; but there must be something that you wouldn't want any geothermal manifestations of any description, would you, uniformly?

Mr. HAMILTON. Well, I think what you were hearing from the other panels today is that a change of even 2° or, you know, in my mind stopping Old Faithful——

Senator WALLOP. Now, let me rephrase the question, because I was not talking about impacts. I was talking about geothermal features themselves.

Mr. HAMILTON. Which geothermal features would be significant and which wouldn't?

Senator WALLOP. I understand what you're saying about significant; but I'm also wondering if we wouldn't want any geothermal manifestation outlined.

Mr. HAMILTON. I think the smaller geothermal, warm springs, are of as big importance as the geysers. I would say those are all significant. We have——

Senator WALLOP. Yeah, but let me try to get at what I'm talking about, because I think we are all agreed on Yellowstone Park and such places; but, you know, not necessarily any warm springs near any further study area or units of the system that are being——

Mr. HAMILTON. I would say that any hydrothermal feature within a national park. And then, in addition, you know, we are talking about other things. In my written statement, for instance, I suggested that we not only need it for national parks, but also State parks. The Federal Government allows leasing around, you know, Thermopolis and Hot Springs State Park. And, you know, I don't think the geology is such there that you can affect it if you allow leasing; but the point is, you could have the same kind of problem, you know, with a State park that you do with a national park.

Now, I think the thermal features in wilderness areas and national parks and State parks, parks and wildlife refuges, areas where wildlife congregate sometimes because of hot water manifestations, I would like to see all these protected. Because I think there are a lot of other places we can pursue geothermal exploration.

One of the problems we have is people are focusing on hydrothermal. They are going after geothermal development next to areas where you have geothermal situations. Those are generally the areas that are important to wildlife, archeologic values. And there is a whole realm

of geothermal that deals with dry rock that is virtually being ignored. And we just think that that is ultimately where we ought to be focusing our attention. And yet whenever you do have a reserve, whether it's a park or a refuge or wilderness area, within—centered around a hydrothermal surface manifestation, that those areas should be protected. They just occur in so few places, and they are so remarkable.

Senator WALLOP. I guess I am, from both perspectives, both from your perspective and the developer perspective as concerned about the lack of scientific merit in buffer zone. You know, I just think that's entirely too arbitrary. I don't know where I want to go. And I'm fairly certain that that's not what I want to end up with.

I want some other things that would—I don't know what it is, and maybe I can find it. So maybe I think if it's lacking in scientific merit in terms of development, it is also lacking in scientific materials in nondevelopment.

In trying to ultimate, there is the protection. We have some broader sets of criteria that we can construct. That is, that is more reliable and more useful than just a buffer zone.

Mr. HAMILTON. It's interesting that the proximity of the park is also something that attracts the developer. In some conversations I had with Donald White of the USGS, he was saying that if Island Park was anywhere else, it would be of very little interest to the developers because of the geothermal potential there is not that great. Because it is next to Yellowstone, it is attractive.

Senator WALLOP. Well, I guess I would have to question whether that has any reality attached to it. It's my understanding that they want it for development of electrical energy. And I can't believe there would be enough to man for the investment that would be required there to make it just because it was next to Yellowstone.

Mr. HAMILTON. No, I don't mean that they wanted to go next to a national park because it's scenic. What I'm saying is they think there might be something there where ordinarily you wouldn't in looking at the surface. It's because of the proximity to Yellowstone.

Senator WALLOP. Anything else?

Senator MELCHER. No.

Senator WALLOP. Again, I thank you folks for coming in and I appreciate your willingness to come here and give your testimony and opinions on the subject.

I can tell there is no easy answer to any of it. And I do believe and you apparently believe that there is some merit with going ahead with the development of geothermal energy as a national resource, providing we can make some credible sense out of the path that we follow.

The record for the committee will remain open for 2 weeks. Witnesses may be asked to respond in writing to something that the study or testimony might not indicate.

Are there any other witnesses in the audience that wish to be heard?

[No response.]

Senator WALLOP. If not, the subcommittee will stand adjourned.

John, thanks for your support.

And the noble reporter, thank you for spending your Saturday afternoon with us.

And I thank you the audience and the witnesses for this testimony.

The subcommittee stands adjourned.

[Whereupon, at 4:07 p.m. the hearing was adjourned.]

APPENDIX

Additional Material Submitted for the Record

JOHN SPELLMAN
Governor

STATE OF WASHINGTON
WASHINGTON STATE ENERGY OFFICE
400 E. Union, 1st Floor, ER-11 • Olympia, Washington 98504 • (206) 754-0700

December 21, 1981

The Honorable Malcolm Wallop
Subcommittee on Public Lands and Reserved Water
Committee on Energy and Natural Resources United States Senate
3204 Dirksen Senate Office Building
Washington, DC 20510

Dear Senator Wallop:

SUBJECT: Subcommittee Inquiry Concerning Implementation, Cost, and Acceptability by Industry of Geothermal Monitoring Programs Near National Parks

Legislation to establish buffer zones to protect the thermal manifestations of Yellowstone, Lassen Volcanic, and Rainier National Parks should, if enacted, provide for leasing and the establishment of a monitoring program acceptable to the United State Geological Survey.

In response to questions by you and Senator Melcher as to how such a monitoring program should be implemented, how much such a program would cost the developer, and if such a program would be acceptable to industry, I have contacted and carried out extensive interviews with several individuals in industry and government. (A complete listing of those individuals contacted and the organizatons which they represent is presented in Appendix I.)

THE REQUIREMENTS OF A MONITORING PROGRAM

The monitoring program will necessarily consist of 1) well siting, 2) well construction, 3) well instrumentation, and 4) data transmittal and analysis.

1) Monitoring Well Siting

The siting of the monitoring well or wells will require as extensive an exploration program as is required for the siting of deep test wells. Because geothermal fluids are usually associated with fracture zones, as fluid transmitting conduits, the monitoring well must intersect the same fracture zone that is providing fluids to the test or production well and which is also indicated to be in connection with thermal manifestations within the national park. Depth of the monitoring wells can be assumed to be equal to those of the test or production wells. A monitoring well drilled within the active production field would be very advantageous as a source for obtaining baseline data. The total number of monitoring wells

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which will be required in a producing area will be dependent upon the size and layout of the producing area. A typical 110 Mwe facility requiring from 15 to 20 producing wells would probably require no more than 3 to 4 monitoring wells.

2) Monitoring Well Construction

Monitoring wells need to be drilled, cased, and cemented in a manner very similar to that required for test or production wells in order to ensure that fluid parameters being monitored are from the same depth and aquifer as is production. The diameter of monitoring wells could conceivably be less than that required by production wells but diameter would be determined by requirements imposed by drilling and rock conditions.

3) Monitoring Well Instrumentation

Monitoring wells will have to be drilled in such a manner as to accept both downhole instrumentation and fluid sampling equipment. Downhole instruments will consist of a fluid pressure measuring tool and possibly instruments to measure temperature and conductivity of the fluids. Tools of this type would be connected to the surface by transmitting cable. Fluid samples would be collected on a regular basis for complete chemical analyses.

4) Data Transmittal and Analysis

Continuous transmittal of data by telemetry from the well head to a central receiving station would greatly increase the potential for detecting minute changes in any of the fluid parameters being monitored. Data could be collected at the central receiving station either in digital form or on a strip recorder. Automatic alarms connected to the data recorder would provide immediate information concerning downhole instrument failure or changes in fluid parameters above or below predetermined values.

THE COSTS OF A MONITORING PROGRAM

The costs associated with the establishment of a monitoring program will be dependent upon 1) well siting, 2) well construction, 3) instrumentation, and 4) data transmittal and analysis. The costs, as presented, do not include those which will be associated with the activities required of the Department of the Interior, the United States Geological Society, or the National Park Service.

1) Monitoring Well Siting

Exploration costs which can be directly attributed to the siting of monitoring wells will be dependent upon the extent of existing geologic data, the distance from the production well to the monitoring

well, and the type and extent of geophysical studies which would be required beyond that carried out during the primary exploration program for test/production well siting. The cost of such a siting program is therefore extremely difficult to predict but should fall in the range of $100,000 to $500,000.

2) Monitoring Well Construction

Well construction costs are dependent upon rock type and depth. Costs, including drilling, casing, and cementing, are averaging nearly $200 per foot for an 8,000 to 10,000 foot well. An exploratory well recently drilled at Meager Mountain, British Columbia, Canada, to a depth of 3,000 meters (10,000 feet), cost 2.5 million Canadian dollars. Cost of drilling shallower wells will be less per foot and should range from $100 to $150 per foot to approximately 6,000 feet of depth. An exploratory well on Mount Hood in Oregon was completed to 6,000 feet and cost $1.25 million. The cost of drilling eleven production wells to an average depth of 8,000 feet was analyzed and the average cost was determined to be $1.3 million per well or approximately $160 per foot. Although injection and/or monitoring wells could possibly be drilled for less, the cost reduction should be considered to be no more than 10 to 15 percent.

3) Monitoring Well Instrumentation

The cost of fully instrumenting a monitoring well would be a very small percentage of the total cost of a monitoring program. Down-hole tools and transmitting cable should cost a maximum of $20,000 to $25,000 per well. Each surface inspection of the tools involving pulling and reimplacement would be expected to cost a maximum of $8,000 for a 10,000 foot well, and proportionately less as depth decreases.

4) Data Transmittal and Analysis

Data from each monitoring well would be transmitted to a central receiving station. Cost of the transmitter, antennas, and central receiving station equipment would cost between $10,000 and $15,000. Personnel to man the central receiving station would be limited and the duties could be handled by existing National Park Service personnel. Automatic alarms and paging systems would ensure full-time reliability of the system with limited involvement of personnel.

ACCEPTABILITY OF BUFFER ZONES AND MONITORING SYSTEMS BY GEOTHERMAL DEVELOPERS

The increased costs which would be associated with the establishing of an acceptable monitoring program would definitely have an adverse effect on the ability of geothermal developers to mount cost-effective exploration and development programs.

The cost associated with the drilling of the first deep exploration/ production well in an area could be tripled if unrealistic requirements for drilling injection and monitoring wells were adopted. However, geothermal developers have indicated that this increased cost could be acceptable if the drilling of injection and monitoring wells were not required until after the completion of the first exploration well and after a determination of the quality of the resource were determined through flow testings. A short flow test (6 to 24 hours) should have no influence on resources outside the immediate producing area. If injection and monitoring wells were required before the initial flow test the increased cost and risk could not be justified.

I appreciate having had the opportunity to respond to the questions raised by you and Senator Melcher. I would be very pleased to assist the Subcommittee in anyway you would find helpful.

Sincerely,

R. Gordon Bloomquist

R. Gordon Bloomquist, Ph.D.
Geothermal Specialist

RBG/cg

Attachment

APPENDIX I

John W. Hook & Associates, Inc.
Geothermal & Mineral Exploration
7315 Battlecreek Road Southeast
P. O. Box 3133
Salem, OR 97302

Eugene V. Ciancanelli, President
Cascadia Exploration Corporation
3358 Apostol Road
Escondido, CA 92025

J. Stauder
System Engineering Division
B.C. Hydro & Power Authority
Box 12121
555 West Hastings Street
Vancouver, B.C.
Canada V6B 4T6

W. R. Benoit
Geothermal Operations, Reno District
Phillips Petroleum Company
86 Keystone Avenue
P. O. Box 6256
Reno, NV 89513

Ted Roper
Telemetry Instruments
Sierra-Misco, Inc.
1825 Eastshore Highway
Berkeley, CA 94710

Donald Klich
United States Geological Survey
12201 Sunrise Valley Drive
Reston, VA 22092

Wendell Duffield
United States Geological Survey
Office of Resource Analysis
345 Middlefield Road MS-18
Menlo Park, CA 94025

Joseph N. Fiore
United States Department of Energy
Nevada Operations Office
P. O. Box 14100
Las Vegas, NV 89114

State of Idaho
DEPARTMENT OF WATER RESOURCES
STATE OFFICE, 450 W. State Street, Boise, Idaho

JOHN V. EVANS
Governor

A. KENNETH DUNN
Director

Mailing address:
Statehouse
Boise, Idaho 83720
(208) 334-4440

January 15, 1982

The Honorable Malcolm Wallop
Subcommittee on Public Lands and Reserved Water
Committee on Energy and Natural Resources United States Senate
3204 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Wallop:

SUBJECT: Subcommittee Inquiry Concerning Geothermal Leasing Activity on Federal and State Lands Within the Island Park KGRA

At the present time there are 168 lease applications filed on 333,399.49 acres of Forest Service land within the Island Park KGRA. Anschutz Corporation has 11 lease applications on 22,670.56 acres, making it one of the largest lease applicants. Actual leasing of these parcels has been delayed, while awaiting the final decision of the Island Park Geothermal Area Environmental Impact Statement.

The state of Idaho has issued 22 leases on 11,034 acres of state owned land in the Island Park area. Occidental Geothermal Inc. holds most of the leases and during 1978 and 1979, two temperature gradient holes were drilled within the KGRA and seven temperature gradient holes were drilled outside the KGRA on private lands. These holes ranged from 500 to 1000 feet in depth. Because the information is proprietary, it is unknown what temperatures were encountered.

The state of Idaho has no intention of terminating the leases that have been issued in the Island Park area. It would be extremely difficult to bar leasing on state and private land without causing a public outcry. Leasing activity has a positive impact upon the State's economy. More leasing revenues and jobs would be a boost to the local and state economy.

The main question to be considered is whether the Island Park Caldera and the Yellowstone system are interconnected. Testimony given by Dr. Robert L. Christiansen of the USGS to the December 12, 1981 regional hearing at Casper, Wyoming, indicated that

these two systems are not connected. Granted, more geological and geophysical work needs to be conducted, but blocking all leasing activity within the Island Park Caldera is not the answer. It is also unknown at this time whether a resource even exists in Island Park. Drilling results around the town of Ashton have been disappointing.

No one is proposing to cap Old Faithful and use the resource for power production. The Yellowstone thermal manifestations should be preserved. However, prudent exploration and development of a resource, if it exists, in the Island Park Caldera should be allowed. It would be irresponsible to ban all leasing in the area.

Thank you for letting me respond to the questions raised by you and Senator Melcher. If you have further inquiries, I will be glad to respond.

Sincerely,

LEAH STREET-MARTIN
Geothermal Program Specialist

LSM/KB

THE WILDERNESS SOCIETY

Northern Rockies Regional Office
107 West Lawrence, P. O. Box 1184, Helena, Montana 59624 (406)443-7350

December 17, 1981

Senator Malcolm Wallop
Senate Office Building
Washington, D.C. 20510

Dear Senator Wallop:

I want to express my appreciation for your Casper field hearing on amendments to the Geothermal Steam Act of 1970 and especially for the opportunity to have presented testimony at the hearing.

I was most impressed by the strong statement you made about insuring the protection of the thermal features of Yellowstone National Park. Indeed, your hearing established that we lack the knowledge to scientifically demonstrate that geothermal exploration and/or development will not adversely effect Yellowstone. It was agreed by all those at the hearing that an adverse effect is any change in the thermal features of Yellowstone caused by geothermal exploration and/or development outside the Park. I was especially pleased to hear you state that the issue is not one of mitigation but, rather, of protection. I wish to request a copy of the hearing record when it is available since I failed to sign up for one at the hearing.

The Wilderness Society stands ready to assist your subcommittee in any way possible in the formulation of legislation calling for the orderly development and protection of our Nation's geothermal resources.

Sincerely,

Bill Cunningham
Regional Representative

BC:dw

91-917 244

"In wildness is the preservation of the world." - Thoreau

Sierra Pacific Power Company
JOE L. GREMBAN
President

January 13, 1982

The Honorable Malcolm Wallop
Chairman, Subcommittee on Public Lands & Reserved Water
Senate Committee on Energy and Natural Resources
204 Russell Senate Office Building
Washington, D.C. 20510

Dear Senator Wallop:

Sierra Pacific Power Company has a vital interest in legislation affecting the use of geothermal resources. Accordingly, we have prepared statements reflecting our position on federal geothermal legislation and our concerns and recommendations with respect to those bills (S.669, S.1516, and H.R. 4067) presently under consideration.

For your information, I am enclosing copies of these statements of our perspective on this issue and arguments regarding the appropriate role for federal government insofar as the use of geothermal resources is concerned.

Sincerely,

Joe L. Gremban

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Sierra Pacific Power Company

FEDERAL GEOTHERMAL LEGISLATION
POSITION OF
SIERRA PACIFIC POWER COMPANY

Sierra Pacific Power Company believes there is significant, potential benefit to its consumers from the cost effective development of geothermal resources. We feel that the production of electricity from geothermal resources is key to the beneficial use of the resource due to the flexibility of transport and use of electricity.

Generation plants can be located at the energy source. The resultant electric energy can then be utilized by all consumers connected to the electric system.

Sierra thus has a clear interest in legislation impacting the exploration and development of geothermal resources, and hopes that the following will receive serious consideration.

POSITION ON FEDERAL GEOTHERMAL LEGISLATION - SIERRA PACIFIC POWER COMPANY

"FEDERAL LEGISLATION SHOULD BE DESIGNED TO ENCOURAGE AND ACCELERATE THE USE OF GEOTHERMAL RESOURCES FOR THE BENEFIT OF CONSUMERS. THE FOLLOWING PRINCIPLES SHOULD BE APPLIED IN PREPARING FEDERAL LEGISLATION:

THE ROLE OF FEDERAL GOVERNMENT SHOULD BE:

- TO EFFICIENTLY ADMINISTER THE EXPLORATION AND DEVELOPMENT OF GEOTHERMAL RESOURCES ON FEDERAL LANDS THROUGH ISSUANCE OF LEASES.
- TO ENSURE REASONABLE PROTECTION OF THE ENVIRONMENT.
- TO ENCOURAGE EARLY TRANSITIONS FROM EXPLORATION TO DEVELOPMENT AND USE.
- TO ASSURE OPPORTUNITIES FOR REASONABLE COMPETITION IN EXPLORATION AND DEVELOPMENT.
- TO PROVIDE ECONOMIC INCENTIVES WHICH COMPENSATE FOR THE RISKS OF EXPLORATION, FIELD DEVELOPMENT, AND CONSTRUCTION OF GENERATION AND TRANSMISSION FACILITIES.

THE ROLE OF THE FEDERAL GOVERNMENT MUST NOT BE:

- TO ITSELF EXPLORE AND DEVELOP THE RESOURCE
- TO CREATE ARTIFICIAL MARKETS, OR TO GIVE PREFERENTIAL TREATMENT TO ANY ENTITY, PRIVATE OR PUBLIC."

APPLICATION OF THESE PRINCIPLES TO CURRENT LEGISLATION

Attached is a summary of Sierra's concerns and recommendations related to H.R. 4067, S. 669 and S. 1516. We urge consideration of the basic principles outlined above, as well as our specific recommendations on current bills.

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FEDERAL GEOTHERMAL LEGISLATION
RECOMMENDATIONS BY
SIERRA PACIFIC POWER COMPANY

SUMMARY

H.R. 4067, S. 669 and S. 1516 are three bills before Congress which, if enacted, would adversely affect Sierra Pacific Power Company's future in geothermal resource development.

Contained herein are recommendations for the modification of those provisions of this legislation which create apprehension on the part of the company in the following major areas of concern:

1. Public power receives preferential treatment.

2. The push from the exploration side of the industry could inhibit the development side of the industry and result in a slower and more costly development of geothermal resources.

3. The door is opened for geothermal development by any federal agency for its use and/or benefit, possibly including development of electric generation for sale as well as use. Implications related to geothermal development by utilities and the use of transmission facilities are troublesome when considered in light of the very high percentage of federal land located in Nevada.

DISCUSSION AND RECOMMENDATIONS - H.R. 4067, S. 1516

H.R. 4067 and S. 1516, companion bills, propose several changes in the Geothermal Steam Act of 1970.

Change 1: The bills provide for the payment of a royalty of 10% to 15% for geothermal electric generation, while the royalty for other uses is 5% to 10%.

Concern - This provision would unfairly penalize the generation industry and its consumers. Since energy in the form of electricity is more easily transported to areas of use, the greatest benefit to society at large may be through generation from geothermal resources. It is not logical that such a beneficial use be discouraged due to an arbitrary decision to increase the cost of generation.

Recommendation - If any royalties are to be charged they should be equal. A more realistic approach would be to not charge any royalties in order to encourage development of the geothermal resources.

Change 2: The bills provide for a ten-year lease with an extension of ten additional years if either administrative delays or marginal economics can be demonstrated to have caused delay in construction of utilization facilities.

Concern - This length of time may be too long to encourage development of resources. The longer the period allowed, the more likely it will be that developers may choose not to develop a resource, but rather to hold back for the maximum time period in anticipation of increased sales prices for geothermal resources.

Recommendation - The current ten-year term, with a possible five-year extension, is more than an adequate time period for development. There should be a provision for public comment on any extension considered, to allow for review by a third party such as Sierra Pacific Power Company, to preclude a developer from "sitting on" a producible lease.

Change 3: The bill provides for an increase from the current 20,480 acre maximum to a 51,200 acre maximum of exploration leaseholds that any one company may hold in any one state. Further, this amount may be increased by the Secretary to 115,200 acres after 1985.

Concern - This increase in the area that can be controlled by any one entity is not going to expedite the development of geothermal. Rather, it allows a company to control more area, resulting in fewer competit ors in the sale of the resource. While the 20,480 acres provision may have been too small, the 115,200 acre provision is much too large.

Recommendation - 51,200 acres seems to be an equitable number. The provision for increase by action of the Secretary should be deleted.

Change 4: If a lease (2500 acres) can be shown to be capable of production, it does not count in the acreage limitation.

Concern - This provision could encourage the misclassification of the real potential of a lease. In addition, the change would decrease the incentive to develop.

Recommendation - Drop this provision altogether or modify it so as to exclude producing leases from the acreage limitation.

Change 5: Leases will be reviewed by the Secretary every twenty years. (This is an increase from the current ten year review schedule.)

Recommendation - While we agree that the longer period conforms more closely to plant/resource life, we urge that the nature of the review and the bases for renewal of leases be clarified.

Change 6: No royalty payment is required for any noncommercial uses of geothermal resources.

Concern - This provision will not put potential geothermal uses on equal and competitive grounds. The result is a possible nonoptimal development of geothermal resources.

Recommendation - Geothermal resources should be treated as energy resources with no distinction among developers as to royalty payments.

Change 7: Federal agencies are encouraged to develop the resource if it will not deter commercial development.

Concern - The provision for federal agencies' "...use or benefit..." is far too broad, opening the door for development for energy sales. Further, the determination of whether federal agencies' development would deter commercial development is left solely to the agency and the Department of Interior. This provision is totally illogical.

Recommendation - The federal government should not actively participate in any phase of resource exploration or development. It should be involved in the proper administration of federal lands that have potential geothermal resources.

DISCUSSION AND RECOMMENDATIONS - S. 669

S. 669 proposes the following additional changes in the Geothermal Steam Act of 1970:

Change 1: No royalties from users if the resource is used for residential, small business or farm, but only if the resource is not used for electric generation in these instances.

Concern - This could encourage some uses of geothermal at the expense of other potentially more economic uses by imposing a discriminatory royalty structure. This is not the proper course to follow in the economic development of a new technology.

Recommendation - See comment on Change 6, H.R. 4067

Change 2: Federal agencies would get a first right to a resource if it would not hamper other commercial use. In addition, the agency may sell excess amounts of the resource to the surrounding community.

Concern - The federal government should not be entitled to any preference in the resource allocation. The bill actually encourages the government to sell the resource and/or get into the energy business.

Recommendation - Federal government activities should be strictly limited to the fair, nondiscriminatory administration of these lands.

Change 3: 10% of federal lands shall be available to publicly-owned bodies.

Concern - This type of preference has led to unfair treatment of all ratepayers in the past (hydroelectric preference).

Recommendation - No preference should be given to one entity over any other. There is no justification for the 10% federal land allocation to publicly-owned bodies.

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